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Economic Impact Analysis of Transit Investments: Guidebook for Practitioners

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Report 35

Economic Impact Analysis of Transit Investments: Guidebook for Practitioners

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Cambridge, MA

with

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Subject Areas

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transit Association (APTA), *Transportation 2000,* also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA; the National Academy of Sciences, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

To save time and money in disseminating the research findings, the report is essentially the original text as submitted by the research agency. This report has not been edited by TRB.

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FOREWORD

By Staff
Transportation Research Board

This report, *Economic Impact Analysis of Transit Investments: Guidebook for Practitioners*, will be of interest to transportation economists and other analysts to assist them in selecting methods to conduct economic impact analyses of transit investments. Although the primary goal of public transportation investments is to improve mobility, economic benefits are also important to transit investment decisions. Consequently, it is important that reliable and defensible analytic methods are used to support decisionmaking.

The primary objective of TCRP Project H-9, *Economic Impact Analysis of Transit Investments: Guidebook for Practitioners*, was to identify and describe a broad array of predictive and evaluative methods used to conduct economic impact analysis of public transportation investments. The research report focuses on 12 methods traditionally used to analyze three categories of transit-related economic impacts:

- *Generative Impacts* produce net economic growth and benefits in a region such as travel time savings, increased regional employment and income, improved environmental quality, and increased job accessibility. This is the only type of impact that results in a net economic gain to society at large.
- *Redistributive Impacts* account for locational shifts in economic activity within a region such that land development, employment, and, therefore, income occur in a transit corridor or around a transit stop, rather than being dispersed throughout a region.
- *Transfer Impacts* involve the conveyance or transfer of moneys from one entity to another such as the employment stimulated by the construction and operation of a transit system financed through public funds, joint development income, and property tax income from development redistributed to a transit corridor.

The report succinctly presents similar information for the 12 evaluation methods including: a brief description of each method; when each should be used; the impacts that each measures; its advantages and disadvantages; the data sources; an example; complementary methods; and a score card on the performance of each method. Methods used to analyze generative impacts are presented first, followed by methods to analyze redistributive and transfer impacts. The latter two tend to be less data intensive, less sophisticated, and more qualitative than the former. Although each method is described separately, the report clearly states that they are typically used in combination to enhance the overall economic analysis.

Having introduced and described 12 evaluation methods traditionally used in public transportation economic analysis, the report then provides guidance for selecting methods and discusses critical issues that affect the selection of evaluation methods. The report goes on to suggest criteria for evaluating and presenting the results of an economic impact analysis after the analysis is completed. These sections include very practical suggestions that should assist analysts to improve the clarity and usefulness of their findings.

The final section of the report discusses two methods—not used extensively in traditional economic analysis of transit investments—to analyze the economic impacts associated with reduced parking requirements and transit-induced accessibility and agglomeration of development.

1.0 Purpose of Document

The primary goal of public transportation investments always has been to improve urban mobility. Nevertheless, it is well understood that transit projects, like all major public investments, can yield important economic benefits. Thus, along with mobility goals, economic development objectives frequently have influenced transit investment decisions, particularly new fixed-guideway systems.

In recent years, transit's potential to produce economic benefits has become increasingly important to the decision-making process for transit investments. Federal budget cuts, along with Congressional mandates to limit federal involvement in urban affairs, including the provision of public transportation, have meant transit proposals must prove their mettle by passing strict benefit-cost tests. Increasingly, policy makers are weighing the potential economic returns of competing highway and transit investments carefully when selecting projects. Notwithstanding the potential mobility, environmental, and broader social benefits of transit systems, emphasis is shifting to the "bottom line" of transit proposals.

To measure the economic impacts of proposed transit investments, reliable and defensible analytical methods are needed. Numerous methods exist and have been in use for decades; however, to date there have been few guidelines for choosing among the methods available and little guidance for interpreting results.

This Guidebook is intended to provide practitioners with the necessary information to select methods to conduct effective economic impact analysis of transit investments. It provides guidance on how to:

- Define economic impacts;
- Understand reasons for conducting economic analysis;
- Select methods and measures appropriate to goals and other critical issues;
- Evaluate the results of the analysis; and
- Present and utilize the results of economic impact analysis.

In addition, descriptions are provided for 12 different methods. Chapters 4 through 8 address these methods that are traditionally used in economic analysis of public transit investments. For each method, information is provided on the types of impacts it measures, its advantages and disadvantages, an example of its application, complementary methods, and selected references. Chapter 9 presents two types of impacts that are not commonly measured in traditional economic analysis of transit investments. Both types of impacts, economic benefits associated with a reduction in parking requirements and the agglomeration of development around a transit station, are measured with one or more of the 12 methods described in Chapter 4.

2.0 Types of Economic Impact Analysis

Most economic impact analyses fall into one of two categories – predictive (*ex ante*) or evaluative (*ex post*). **Predictive economic impact analysis** is used to forecast the likely economic impacts of a proposed transit investment. Impact analyses conducted as part of Major Investment Studies (MISs) and Environmental Impact Studies (EISs) are predictive. Most practitioners are interested in conducting predictive analysis to evaluate the potential economic impact of one or more alternative transit investments.

Evaluative economic impact analysis is used to gauge the effects of a transit investment after it has been implemented. Evaluative studies typically involve examining economic conditions (variously defined) before and after completion of the transit investments, and in many cases have yielded useful insights into the roles that transit has played in stimulating economic growth and development. Such analyses also provide useful inputs for improving future predictive analyses.

In addition, most economic impact analyses involve either **modal comparisons** or **no-project comparisons. Modal comparisons** analyze the relative impacts of an investment in, for example, light rail transit compared to a comparable investment in alternative modes, such as highway improvements, a bus system, or high-occupancy vehicle (HOV) facilities.

For **no-project Comparisons**, practitioners are often asked to measure their region's economic performance with and without the transit investment. This comparison assumes that the alternative (or base case) to the construction and operation of a new or larger transit system is no additional investment. This type of analysis – if properly undertaken – measures the net economic benefits of using local revenue sources to fund public transit. Such local sources usually include taxes (i.e., sales, fuel, property, etc.) or fees (i.e., vehicle registration, development impact, bridge tolls, etc.) and represent a transfer from the private sector to the public sector. No-project comparisons are intended to demonstrate the net impact of transit on regional economic growth.

3.0 Definitions of Economic Impacts

There is considerable debate among transit professionals, scholars and researchers regarding what constitutes an economic impact. Definitions differ for a variety of reasons, whether due to the policy context of a particular study, the geographic area of interest, or misunderstanding of economic theory. This section clarifies the definitions of economic impacts and distinguishes between impacts that produce net economic growth from those that redistribute existing economic activities, or result in financial transfers.

The broad range of transit investment impacts that frequently are defined as "economic" can be classified in three categories: generative, redistributive, and financial transfer. Within each category, there are several types of impacts. These are summarized in Table 3.1, and described below.

Table 3.1 Categories of Transit-Related Economic Impacts

Generative Impacts	Redistributive Impacts	Financial Transfer Impacts
• User benefits (travel time savings, safety benefits, changes in operating costs)	• Land development (e.g., clustered development around transit stations)	• Employment and income growth related to system construction, operation, or maintenance
• Employment and income growth unrelated to system construction, operation, or maintenance	• Employment and income growth due to land development	• Joint development income to local agencies
• Agglomeration/urbanization benefits (e.g., higher productivity, lower infrastructure costs)	• Increased economic activity within corridor	• Property tax impacts
• External benefits (e.g., air quality)		
• Accessibility benefits (e.g., access to employment)		
• Reduced development cost due to reduced parking		

3.1 Generative Impacts

Generative impacts produce **net economic growth in a region.** They arise from utilizing previously underused resources or using resources more efficiently. They reflect increases in economic productivity, the competitive advantage of a region, and quality of urban living, and represent a net economic gain. Impacts that fall into this category represent economic impacts in the purest sense. They measure net benefits to society at large derived from the transit investment. Generative impacts include the following:

- **User Benefits** –A transit investment may reduce the travel time of some trips for some users of the transportation network. Business travelers and residents who save time traveling benefit as more time becomes available for leisure, family, work, or other pursuits. Benefits accrue to firms to the degree that transportation infrastructure functions as a direct input into their production processes. Transit infrastructure causes generative gains if it lowers the costs of transporting factor inputs and shipping production outputs by decreasing the amount of time required for such goods movements. Since urban transit systems move passengers, not goods, they rarely lower materials hauling and goods distribution costs. By relieving congestion, however, transit systems can lower firms' transportation costs indirectly. To the degree workers can more conveniently commute to their jobs, for example, labor productivity could be expected to increase.

  As the nation's economy shifts from a heavy manufacturing base to a more service-oriented economy, transit's direct productivity benefits may become more substantial. Transit, for instance, may reduce the input costs of office-related businesses by facilitating face-to-face meetings and speeding business-related intra-metropolitan travel. A downtown firm in Atlanta, for instance, that relies on easy access to Hartsfield International Airport on a regular basis, would experience direct economic benefit from having its employees efficiently linked to the airport by the Metropolitan Atlanta Regional Transit Authority (MARTA).

  Considerable research has been conducted to quantify this benefit in monetary terms by deriving a "value of time" for different types of travel (primarily work and non-work trips.) The travel time benefits mainly will accrue during peak periods (Small, 1992) when roadway congestion is greatest. Benefits for work-related trips generally are valued at between 50 to 100 percent of the prevailing wage rate for the affected workers. Benefits for personal trips typically are valued lower. Many state departments of transportation and metropolitan planning organizations have established standard values of time for their jurisdictions.[1]

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[1] See Jack Faucett Associates, *Value of Travel Time,* study memorandum submitted to the U.S. DOT, Federal Highway Administration, Washington, D.C., September 18, 1989.

See also Ted R. Miller, *The Value of Time and the Benefit of Time Savings,* The Urban Institute, Washington D.C., 1989, and Garder, *Value of Short Time Periods,* Draft Report, University of North Carolina, Highway Safety Research Center, Chapel Hill, North Carolina, May 1989.

Other user benefits include safety (i.e., reductions in accidents) and changes in operating costs. The National Transportation Safety Board (NSTB) has established monetary values for estimating the costs of fatalities, personal injuries, and property damage that are typically used to estimate safety benefits.[2]

- **Regional Employment and Income Growth** – The benefits of travel time savings also may be reflected in gains in regional income and employment as new businesses are attracted to a region as a direct result of the improved transportation system. For example, reduced travel times in a region that result from improved transit services may induce growth by attracting new firms and workers to a region. This in turn can attract new companies and investments to a region by giving local firms a competitive advantage and making a region a more attractive place for labor to locate. If workers are willing to accept lower wages to locate near a transit corridor, this can likewise lower firms' labor input costs. If this growth is not related to the construction, operation, or maintenance of the transit system,[3] and clearly can be attributed to the transit investment, then the growth, whether measured in terms of a net change in employment, output, or income, represents net regional economic gain.

- **Agglomeration and Urbanization Benefits** – The clustering of offices, retail shops, hotels, entertainment centers, and other land uses around rail transit stops produce economic benefits in a number of ways. Agglomeration benefits reflect the higher productivity, creativity, and synergy associated with increased face-to-face contact, access to specialized labor, and external transactions made possible by more compact, transit-served development. A related impact is urbanization benefits – the reduced outlay for urban infrastructure, such as streets, water lines, and sanitation facilities, that result from the more compact patterns of development that transit service makes possible. Since both agglomeration and urbanization benefits accrue from transit-induced compact development, they are strongly associated with high levels of accessibility.

  Accessibility benefits, and thus, indirectly, agglomeration and urbanization benefits, are normally capitalized into land values and rents. Parcels enjoying these benefits are in more demand, and consequently rents are bid up for these choice locations.

- **External Benefits** – These are benefits that accrue to all of society, not just to transit riders, from the use of transit. External benefits largely are attributable to the attraction of motorists to higher-occupancy (and thus more resource-efficient) transit modes, and normally include improvements to the environment, such as reduced emissions of air pollution and greenhouse gases, reduced traffic-related noise and road vibration, and reduced fossil-fuel consumption. The true economic value of these external benefits remains controversial,[4] but several studies have attempted to attach price tags to them.

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[2] See also an internal memo from the Office of the Secretary, Department of Transportation, *Treatment of Value of Life and Injuries in Preparing Economic Evaluations*, January 1993.

[3] Employment changes related to construction, operation and/or maintenance of a transit system are classified as transfer impacts, and are discussed later.

[4] For example, the epidemiological and health impacts of air pollution remain a significant source of debate. Some researchers have argued that motor-vehicle-generated ozone causes health

(Footnote continued on next page...)

One study estimated that the air pollution cost of motoring to be around three cents per vehicle-mile traveled for metropolitan Los Angeles, the only extreme non-attainment area in the United States.[5] Other studies have assigned higher costs per vehicle-mile attributable to air pollution.[6] Additional research is needed to more reliably quantify these impacts.

- **Job Accessibility Benefits –** Some argue that transit provides economic benefits by providing accessibility to jobs, medical centers, retail stores, and other destinations for mobility-restricted populations – the poor, seniors, disabled individuals, and those too young to drive. While improved accessibility promotes equity, there are often economic efficiency implications as well. If, for example, improved transit access allows some inner-city residents to reach jobs and achieve gainful employment, and in so doing reduces unemployment, this represents a welfare gain not only to the individual, but also to society at large, provided that the cost of the transit service is lower than the cost of unemployment and other social welfare benefits. Methods for measuring job accessibility benefits have not been well developed.

- **Reduced Parking –** Transit also yields stationary benefits, measured mainly in the form of lower necessary capital and land acquisition outlays for parking facilities, which can be translated into higher land values for development sites served by transit. Commercial parking standards (e.g., number of spaces per thousand square feet of building space) are typically far lower in central cities, where transit services are most intensive, than in suburbs, where services are more sparse. Since structured parking facilities can cost more than $20,000 per parking space, substantial cost savings can accrue to developers.[7]

Transit provides other benefits that are related to a reduced need for parking. With the average parking space requiring around 350 square feet (including aisles and driveways), every space removed as a result of transit can make more land available for development, or allow it to remain as open space. Land savings is clearly a generative benefit since the supply of land is fixed and finite. The cost savings, the increased development capacity of the parcel, and the value of open space should be reflected in higher land values. In addition, reducing the amount of land consumed for parking helps to create compact development patterns which, as noted above, may offer infrastructure cost savings as compared to more dispersed development.

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problems, lost labor hours, and agricultural crop losses. One study estimates that air pollution causes annual crop damage of between $10 billion and $200 billion. See: James MacKenzie, Roger Dower, and Donald Chen, *The Going Rate: What it Really Costs to Drive*, World Resources Institute, Washington, D.C., 1992.

[5] Small, Kenneth and Camilla Kazimi, "On the Costs of Air Pollution from Motor Vehicles," *Journal of Transportation Economics and Policy*, January 1995.

[6] See: Peter Miller and John Moffett, *The Price of Mobility: Uncovering the Hidden Costs of Transportation*, Natural Resources Defense Council, Washington, D.C., 1993. Miller and Moffett estimate the cost of air pollution to be four to seven cents per mile traveled in a motor vehicle in urban traffic.

[7] Shoup, Donald. *The True Cost of Free Parking*, Parking Today, August 1997.

3.2 Redistributive Impacts

Redistributive impacts account for locational shifts of economic activity within a region. They quite likely represent economic activities that would have occurred anyway in the absence of the transit investment, but in a more dispersed manner. Economists argue that, because these impacts reflect a redistribution of existing economic activity, they should not be classified as "economic" impacts; however, they frequently are of great interest to local policy makers, whose goals may include the stimulation of economic activity in a specific location. Redistributive impacts include the following:

- **Land Development** – The clustering of development around a transit stop may be considered an economic benefit if a goal of a project is to stimulate private investment or reinvestment within a transit corridor. Potential impacts can be measured in terms of square feet or dollar value of development by type of land use. They are realized only if regional economic conditions and site-specific real estate market conditions are supportive.

- **Employment and Income Growth** – Just as a transit investment can redistribute land development to a corridor, it also can shift jobs to a transit corridor. Existing firms may move from elsewhere in the region, or firms that were going to locate within the region anyway may choose to locate near transit stations. This redistribution of employment can produce income growth in the corridor as well, to the extent that people working within the corridor also live there. However, a corresponding reduction (or smaller gain) in employment and income will occur elsewhere in the region. This shift in the location of employment and income growth is of interest when economic development or redevelopment is a goal of the transit investment.

3.3 Transfer Impacts

Transfer impacts involve the conveyance of monies from one entity to another, and frequently are reported as economic impacts. In actuality, they represent accounting or financial impacts – shifts from one accounting ledger to another. Transfer impacts include the following:

- **Regional Employment and Income Growth Related to Construction, Operation, and Maintenance of the Transit System** – Rail projects can mean an infusion of hundreds of millions of federal and state dollars into a local economy, particularly given that 80 to 90 percent of rail investment costs frequently are covered through capital grants. Dollars invested in the construction, operation, and maintenance of new rail projects result in numerous direct full-time jobs; and each of these jobs spurs additional indirect and induced jobs as new income is spent and respent in the economy.[8] Most employment and income gains directly attributed to building, operating, and servicing transit facilities represent a financial transfer, since those jobs exist as a result of dollars being transferred from federal to local treasuries, and from taxpayers to public entities (i.e., transit agencies). The money spent on a transit investment might otherwise have been spent in alternative ways (e.g., construction of a sewer plant, welfare payments, education, etc.), or not spent, resulting in deficit reduction or reduced taxes. Each of these alternatives could produce economic impacts equal to or greater than those that the transit investment produced, and so the impacts may not be a net gain to society at large.[9]

- **Joint Development Income** – In metropolitan Washington, D.C., New York, Philadelphia, and a few other rail-served areas, local transit agencies receive millions of dollars in annual revenues through joint development arrangements, such as air-rights developments and station connection fee programs. One study put the annual revenues received by U.S. transit agencies through joint development during the 1977-1988 period at around $240 million (Cervero, Hall and Landis, 1992). These payments represent financial transfers, mainly from private land developers to transit agencies.[10]

- **Property Tax Income** – Just as joint development income to transit agencies is a financial transfer, so are the increased property tax receipts from station area development that accrue to local municipalities. As long as transit's urban form impacts are redistributive, then shifting growth to a transit corridor from elsewhere in the region often means tax income is transferred from one municipality to another (or one location in a single municipality to another location in that same municipality.)[11] Financial transfers also occur between private and corporate property-owners and local governments. Arguments sometimes are made that since rail transit investments consume less land than highway and freeway projects, the freeing of land for private consumption (from tax-exempt public uses) increases property tax income. This income also qualifies as a transfer impact.

The purpose in differentiating between generative, redistributive, and transfer impacts is to ensure that impacts are reported clearly and accurately. While only generative impacts

[8] See reference for industry translator variable: Local Transit Construction (PVID 38) on page 11-35, Regional Economic Models, Inc., *Model Documentation for the REMI EDFS-53 Forecasting and Simulation Model*, Amherst, Massachusetts, (413) 549-1169 or remi@croker.com, 1996.

[9] From a regional perspective, these jobs may represent a net gain if federal dollars otherwise would not have been spent in the region.

[10] In addition to financial transfer impacts, joint development also may produce redistributive or generative impacts. Whether the impact is redistributive or generative depends on whether the development that occurs as a result of a joint development program is a redistribution of growth that would otherwise have occurred elsewhere in the region or state, or net growth that would not have occurred in the absence of the joint development program.

[11] If the shifts result in agglomeration economies, then property tax revenues will increase because of higher land values. This actually represents a net financial gain to a local jurisdiction. The dollar amount of this gain, however, should be expressed as a generative benefit associated with increased agglomeration and accessibility. Including it as a financial benefit as well will result in double-counting.

result in net economic gains to society at large, redistributive and transfer impacts also can be important to agencies and organizations trying to gain support for a transit investment, and may represent net economic gains to an individual region. The goals of the impact analysis, and the audience to whom the analysis results will be presented, will dictate which impacts should be measured. The appropriate methods to be employed will be influenced by the impacts to be measured. Still, it is important that analysts be clear and concise as to whether the impact of a transit investment is generative, redistributive, or transfer in nature.

■ 3.4 Enumerating vs. Double-Counting Transit's Impacts

As just noted, a transit investment may produce a variety of types of economic impacts. Unless the different types of impacts are defined and differentiated clearly, they can easily be "double-counted" or, conversely, overlooked. The issue of double-counting is especially important, and warrants closer examination.

Different stakeholders frequently are interested in specific types of transit-induced impacts. For example, the development community might be most interested in a transit investment's projected land value and parking reduction impacts. Local governments in a corridor might focus on potential employment growth impacts. A regional planning agency and a corridor's residents might be most concerned with potential travel time savings. A state legislature might want to know about the net effects of an investment to the state treasury. Thus, the "consumers" of an analysis will dictate which impacts are enumerated. It even might be appropriate to gauge the same impact in several ways. Nevertheless, when measuring the investment's total (cumulative) economic impact, great care must be taken not to add together impacts that are, in reality, measuring the same thing. To do so would be double-counting, and would result in an overstatement of the true economic impact of the investment.

As an example of double-counting, consider a case in which a transit investment is found to have yielded travel time savings worth $2 million annually, and property value increases (measured in terms of lease rates and sale prices) of $3 million annually. While it may be appropriate to discuss each of these impacts separately, it would be inaccurate to conclude that the transit investment produced a total annual benefit of $5 million. This is because the increase in property values is due, in large measure, to the travel time savings. That is, the value of the improved access to properties in the transit corridor is capitalized into the lease rates and sale prices of the properties. Thus, adding together the travel time benefits and the property value benefits would be counting the same impact twice, and would exaggerate the benefits of the transit investment.

Summary – Defining Economic Impacts

Economic impacts fall into one of three categories: generative, redistributive, and financial transfer. Generative impacts represent a net economic gain or loss to the region. Redistributive and financial transfer impacts reflect shifts of economic activity from one location to another.

Generative impacts
- User benefits;
- Regional employment and income growth;
- Agglomeration and urbanization benefits;
- External benefits;
- Job accessibility benefits; and
- Reduced parking.

Redistributive impacts
- Land development; and
- Employment and income growth.

Financial transfer impacts
- Regional employment and income growth related to construction, operation, and maintenance of the transit system;
- Joint development income to local agencies; and
- Property tax income.

The same impact can be measured in more than one way. It is important to avoid double-counting of impacts.

3.5 Criteria for Evaluating Analytical Methods

The following five principles represent universally accepted features of good analytical methods and study designs.[12] Methods used for estimating the economic impacts of transit investments and policies can be evaluated based on these five principles or criteria. The methods reviewed in this report are rated according to how they fare regarding these criteria.

- **Validity** – Indicates the degree to which the method accurately measures and portrays the phenomenon under study. There are two types of validity:

[12] Sources: C. Selltiz, L. Wrightsman, and S. Cook, *Research Methods in Social Relations*, New York: Holt, Rinehart, and Winston, 1976; B. Chadwich, H. Bahr, and S. Albrect, *Social Science Research Methods*, Englewood, New Jersey: Prentice-Hall, 1984.

1. **Internal Validity** – The techniques and measures applied allow the effects of an action or event (e.g., a transit investment) to be unambiguously determined so as to allow one to accurately draw cause-effect inferences. This criterion essentially means that controls have been properly introduced to allow the unique effects of an action or event to be isolated and all confounding influences to be removed.

2. **External Validity** – The findings are generalizable from the specific cases to a larger domain. This means the core findings in one location can reliably be applied to another location.

- **Reliability** – Indicates the degree to which the method provides consistent and stable results when applied repeatedly to the same case or cases.

- **Data and Resource Demands** – Indicates the degree to which the analysis requires significant amounts of data, time, skills, budget, and expertise to conduct the work. Related principles are parsimony and elegance. Parsimonious and elegant methods and study approaches aim to express relationships in as simple terms as possible, allowing the truly important elements of a relationship to be understood and minimizing the risks of mismeasurement, poor estimation, or error propagation.

- **Transparency** – Indicates the degree to which the methods, assumptions, and results are understood and accessible to an audience beyond methodologists themselves.

No method scores high on all five of these criteria. If it did, it would be universally applied and all other methods would be cast away. As will be shown, the methods applied to evaluating the economic impacts of transit investments and policies vary markedly according to these criteria. It is for this reason that care must be given to selecting and applying a particular method in light of the tradeoffs that must be made across these criteria. A score card at the end of each method's description grades its performance according to these criteria.

4.0 Inventory of Common Methods

A wide range of methods exist for measuring the economic impacts of transit investments. Table 4.1 lists twelve methods that traditionally have been used for transit economic impact analysis. The table identifies the types of impacts each method most typically is used to measure, and whether the method is used for predictive or evaluative studies.

Following the table is a summary overview of each method. The summary includes a short description of each method, identifies when it is used and what impacts it is used to measure, and describes its advantages and disadvantages. Other complementary methods are noted, and references for studies that have used each method are identified.

Methods typically employed to measure generative impacts are listed first. These methods tend to be methodologically sophisticated and produce quantitative results. They tend to be generic in that they can be used to measure a range of impacts, whether economic, social, or physical in nature.

Methods that measure redistributive and transfer impacts then are presented. Compared to generative impacts, these methods tend to be less data intensive and sophisticated, and often produce more qualitative results.

Most of the methods presented are not mutually exclusive. For example, estimating user benefits usually involves using a transportation network model, regression analysis, and applying rates and factors. Similarly, real estate market analysis typically includes physical conditions analysis, interviews, and sometimes rates and factors. For simplicity, each method is described separately, but complementary methods are listed to provide guidance on which methods typically are combined to enhance the analysis.

Table 4.1 Methods for Measuring Economic Impacts of Transit Investments *Generative Impacts*

Impacts	Methods					
	Regional Transportation – Land Use Models	Benefit-Cost Analysis	Input-Output Models	Forecasting and Simulation Models	Multiple Regression and Econometric Models	Non-Statistical and Statistical Comparisons
User Benefits[1]	P	P				
Employment and Income Growth[2]			P	P		
Agglomeration/ Urbanization Benefits[3]	P			P	E	E
External Benefits[4]	P				E	
Social Benefits[5]	P				E	E
Reduced Development Costs[6]					E	E

Redistributive Impacts

Impacts	Case Comparisons	Inter-views/ Focus Groups/ Surveys	Methods					
			Physical Conditions Analysis	Real Estate Market Analysis	Fiscal Impact Analysis	Development Support Analysis	Regression Models	Statistical and Non-Statistical Comparisons
Land Development and Redevelopment[7]	P	P,E	P,E	P		P	P,E	E
Employment and Income Shifts[8]	P	E				P		E
Increased Economic Activities[9]	P	E						

---

[1] Includes travel time savings, safety benefits, and changes in operating costs.

[2] Other than growth related to facility construction and operations.

[3] Increased productivity and/or lower public infrastructure costs.

[4] Includes impacts such as improved air quality and reduced noise pollution.

[5] Includes impacts such as improved accessibility for the poor, physically disabled, and elderly.

[6] In particular, reduced parking costs.

[7] Compact, transit-oriented development.

[8] Intra-regional.

[9] Increased retail sales, for example.

Financial Transfer Impacts

Table 4.1 *(continued)*

Impacts	Case Comparisons	Inter-views/ Focus Groups/ Surveys	Methods: Physical Conditions Analysis	Real Estate Market Analysis	Fiscal Impact Analysis	Development Support Analysis	(Multipliers from) Input-Output Models
Employment and Income Growth[10]							P
Tax Impacts[11]		E			P	P	
Joint Development[12]	P	P,E		P			

P = Used for PREDICTIVE studies.
E = Used for EVALUATIVE studies.

4.1 Methods Used to Measure Generative Impacts

Method: Regional Transportation–Land Use Models

Description

Long-term economic benefits of investment in public transit are derived from switching auto trips to transit trips. This substitution of high-occupancy transit vehicles for low-occupancy private autos improves the transportation system's efficiency given a finite capacity to move people and goods. Travel demand models can measure the change in the whole transportation system's performance that results from an improvement in the transit system.[13] These changes may be separated into two types: user benefits and non-user (external) benefits. User benefits consist of:

- Travel time savings;
- Vehicle operating and parking cost savings;

[10] Growth related to construction, operation, and maintenance of the transit facility.

[11] Increased revenues from property, sales, income, and other taxes.

[12] Connection fees, impact fees, public-private partnership, assessment districts.

[13] Both performance and spending benefits include direct, indirect and induced jobs or earnings. Note that jobs and earnings are two similar ways of accounting for the same benefits; thus, adding them together would be double-counting.

- Reduced accidents; and
- Emergency back-up or overflow reliever value.

Non-user (external benefits) accrue to the population as a whole and include:

- Air quality improvements;
- Energy conservation; and
- Social equity.

Travel demand models predict changes in travel behavior (i.e., mode choice, route choice, departure time, destination, etc.), traffic volumes, and travel times on network links. These outputs are used to derive user and non-user impacts. These impacts are then converted to dollar equivalents (i.e., monetized) and used to estimate the following economic benefits:

- The cost of doing business in the region affected by "on-the-clock" travel;
- Access of business to labor markets (i.e., wage premiums demanded by workers for longer, more congested commutes);
- Cost of living and personal spending patterns for individuals and households, including the costs of personal travel; and
- Attractiveness of the area as a place to live, work and visit (i.e., remaining wage and housing price differentials not explained by other impacts).

When to Use

Travel demand models primarily are used for predictive studies. They are particularly useful when the goal of the analysis is to compare alternatives, measure the regional economic (development) impacts of a project, or secure public financing.

Impacts Measured

Transportation demand models can be used to estimate how different levels of public transit investment affect total transportation costs. Although the specific type of transit investment must be considered, the following transit outputs from the region's transportation demand model are generally needed to estimate changes in transportation costs:

- Number of transit boardings by trip purpose;[14]
- Number of transit person trips by trip purpose;

[14] Trip purpose should distinguish between on-the-clock travel (thus a direct cost of businesses) and home-based work trips (commute), home-based shop trips, and home-based other trips which are typically travel not included in direct business costs.

- Percent of boardings representing transfers;
- Average trip length by trip purpose;
- Average transit vehicle occupancy;
- Total transit passenger-miles by trip purpose;
- Average transit in-vehicle travel time (IVTT);
- Average transit out-of-vehicle travel time (OVTT);
- Average out-of-pocket cost per vehicle-mile traveled (VMT);
- Rail mode split of total transit boardings for rail; and
- Rail mode split of total transit person trips.

In addition to these transit outputs, a complete accounting of performance improvements from the region's transportation demand model should include changes to private auto travel. The most common outputs needed from the travel demand model include:

- Number of vehicle trips by trip purpose;
- Number of vehicle person trips by trip purpose;
- Average vehicle occupancy by trip purpose;
- Total VMT (segmented by facility type – e.g., mixed flow, HOV);
- Total vehicle-hours traveled (VHT) by trip purpose;
- Average auto OVTT;
- Total auto OVTT;
- Average out-of-pocket cost per VMT;
- Average number of fatality accidents (by facility type);
- Average number of injury accidents (by facility type);
- Average number of property damage accidents (by facility type); and
- Average trip length by trip purpose.

It should be noted that transportation demand models can isolate many of these transportation impacts below the regional level (e.g., within a subarea, a traffic analysis zone or TAZ, and along a corridor). These local impacts may then be aggregated to a regional level.

Finally, some transit investments will impact the performance of goods movement on the regional system. If a transit investment decreases autos from congested roadways, freight can now move more quickly, reliably, and safely along these previously congested roadways. Such improvements provide direct and significant benefits to the region's industrial competitiveness. To estimate these benefits, the following performance outputs are needed from the regional transportation demand model:

- Percent of heavy truck trips to the total vehicle trips;
- Percent of heavy truck VMT to the total vehicle VMT;
- Percent of heavy truck VHT to the total vehicle VHT;
- Average truck trip length;
- Average value of truck cargo;
- Average number of fatality accidents (per 100,000 VMT);
- Average number of injury accidents (per 100,000 VMT); and
- Average number of property damage accidents (per 100,000 VMT).

Advantages

Travel demand models provide the most accurate, systematic, and comprehensive method for quantifying the changes in the regional transportation system's performance due to transit investments. The changes in transportation performance are measured in terms of user and non-user benefits, such as travel time savings, improved travel time reliability, reduced accidents, reduced vehicle operating costs, etc. No other method provides quantitative values for these benefits and allows for accurate comparison between alternative investments.

Disadvantages

Measuring improvements in the regional transportation system requires the analyst to use a computer program that is extremely complex, data hungry, and requires expertise to be used properly. The leading software packages (e.g., EMME2, TRANSCAD, MinUTP, and TRANPLAN) are expensive to install, operate, and maintain. Although most metropolitan regions maintain such models, their staff may lack the expertise to extract the necessary outputs from the models.

Depending on the sophistication of the model, the transit ridership data collected, and the expertise of the modelers, some travel demand models are reasonable tools for estimating travel behavior of transit systems. In general, however, most models have not always been as good at forecasting changes in transit performance as they are at simulating auto travel.

Data Sources

These computer models simulate travel behavior in the region's transportation network. In general, they apply a four-step process to extensive travel data collected from roadways, intersections/interchanges, transit systems, and numerous other sources.[15] Well maintained travel demand models usually embody most of the data required for the

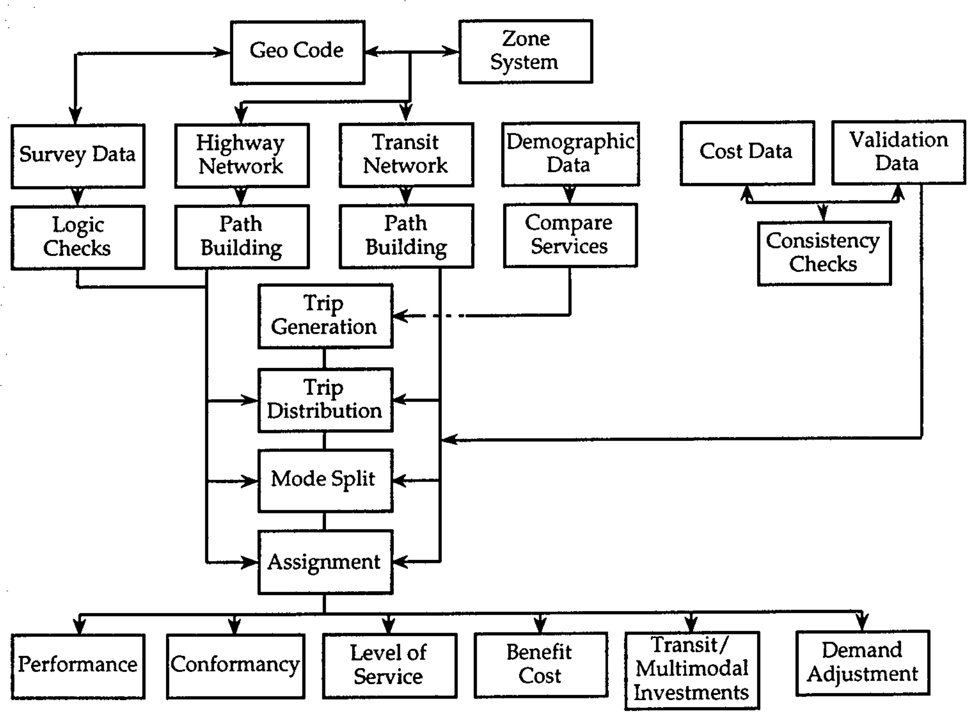
[15] The four steps consist of trip generation, trip distribution, mode choice, and assignment.

analysis, although it is necessary on occasion to conduct a revealed and/or stated-preference survey to collect specific transit data. Due to the data requirements, this method would be feasible only if a model were available.

Example **Travel Demand Modeling, Tren Urbano Rail Project:** A recent study examined the effects of a new transit system on the transportation network, economy, and environment of the San Juan metropolitan area (SJMA). The first phase of the Tren Urbano (Urban Train) project connected major population and employment centers in three municipalities of the SJMA. The analysis of the 10-mile rail project, which included a number of alignment alternatives, involved the development and application of a regional travel demand model to quantify transportation, economic, and land use impacts of the transit system.

The analysis made extensive use of a four-step travel demand model to estimate travel time savings, changes in regional VMT vehicle operating cost savings, intersection level of service improvements, and air quality improvements. The four steps, consisting of trip generation, trip distribution, mode choice, and trip assignment, were developed and applied for use in evaluating the impacts of the Tren Urbano system. An overview of the four-step modeling process used for this project is illustrated below. Brief descriptions of each step in this process follow.

Overview of the Four-Step Modeling Process



Trip Generation – Trip generation models for the Tren Urbano project contained submodels for trip productions, trip attractions, special generators, and external trips. The trip production and attraction submodels were estimated from recently collected household travel survey data, 1990 Census data, and population, employment, and other socioeconomic variables (income) representative of the SJMA. These submodels represented the number of trips generated by households and employers (businesses) in the SJMA.

The special generator (representing atypical land uses such as airports and hospitals) and external trip submodels were estimated from traffic counts. Each sub-model, with the exception of the external trip sub-model, were used in disaggregate form to estimate separate trip purposes, including:

- Home-based work;
- Home-based other;
- Home-based school/university; and
- Non-home-based.

These trip purposes were estimated separately in order to identify the unique travel demand characteristics that had an impact on the SJMA transportation network. Each trip generation sub-model predicted daily person travel by traffic analysis zone (TAZ), representing the analysis areas contained within the SJMA, for the average weekday.

Trip Distribution – Trip distribution models for the Tren Urbano project were estimated to link the trip productions and trip attractions generated in the previous modeling step. Trip distribution models were developed separately for each trip purpose and were estimated using the gravity model. The gravity model generates trip interchanges on the transportation network as a product of the trip attractions and productions divided by an exponential function of travel cost (usually time). Gravity models developed for the Tren Urbano project considered the following inputs:

- Travel impedances (travel times) generated from the transportation networks (representing the roadway and transit systems of the SJMA);
- Trip productions and attractions generated in the trip generation step;

- Trip length frequency data obtained from the household travel survey; and

- Friction factor curves generated from the gravity model calibration process.

Mode Choice – Mode choice models for the Tren Urbano project were estimated to predict the potential travel mode choices on the SJMA transportation system. Models were developed using nested logit modeling techniques for the home-based work, home-based non-work (combination of home-based other and home-based school/university purposes), and non-home-based trip purposes. Travel mode choices included auto (drive alone) and transit (public or jitney, Metropolitan Bus Authority, privately contracted bus, and ferry), and transit access (walk and drive) modes.

Nested logit models were implemented to accurately identify the potential mode choices that are not equally competitive (in reality) with one another (i.e., single-occupancy vehicle, SOV, versus commuter rail). This structure assumed that modes (auto, transit), submodes (SOV, HOV), and access modes (auto-park/ride, walk) were distinct from one another and represented a unique set of potential travel choices. Models were estimated using household travel survey data, transportation network travel times, transit on-board travel survey data, and socioeconomic indicators such as income, out-of-pocket travel costs, transit wait times, and other variables.

Trip Assignment – Trip assignment models for the Tren Urbano project were estimated separately for peak hour and daily periods to identify the unique transportation network and travel behavioral characteristics of each time period. Trip assignment models were generated using outputs from the previous modeling steps (generation, distribution, mode choice) and the outputs from additional models (auto occupancy, time-of-day). The trip assignment technique used the equilibrium formulation. This technique considered the following attributes:

- Congestion levels and resulting travel speeds were consistent with reality by time period;

- Tolls and travel costs were directly modeled; and

- Intersection and link delay were also directly modeled.

Model Outputs and Applications – The travel modeling system developed for the Tren Urbano project was run and applied to perform the following analytical tasks:

1. Identified the appropriate locations for rail stations, park-and-ride facilities, and multimodal/intermodal stations based on ridership forecasts of alternative Tren Urbano alignments that were modeled.
2. Determined the appropriate service plans for express, local, and feeder bus systems to connect with the Tren Urbano system.
3. Measured roadway network and transit network levels of service, impact, and congestion levels.
4. Produced travel demand outputs used to measure systemwide and local air quality and intersection level of service impacts associated with alternative alignment alternatives and time-of-day scenarios.
5. Generated travel demand outputs used to identify the alternative and feasible financial plans to support the construction, operation, and maintenance of the Tren Urbano system.
6. Generated travel demand outputs to identify benefit/cost scenarios for the Tren Urbano system based on alternative alignments, financial plans, and ridership results.

Complementary Methods

Transportation demand models are the core application for the evaluation of transit's economic impacts. The models provide user and non-user benefits that are then monetized and used in an economic forecasting and simulation model. Sketch planning techniques can be used as substitutes for this.

Method's Score Card

The following score card grades the performance of travel demand models according to five criteria described in Section 3.5. These five principles represent universally accepted features of good analytical methods and study designs.

Criteria	Low	Medium	High
Internal Validity			✓
External Validity		✓	
Reliability		✓	
Minimal Data and Resources	✓		
Transparency	✓		

Selected References

Cambridge Systematics, Inc., *Final Report: Investment in Public Transportation: The Economic Impacts of the RTA System on the Regional and State Economies* (Project A2077), prepared for the Chicago Regional Transit Authority, January 1995.

Cambridge Systematics, Inc., *Economic Impacts of the Southwest Indiana Highway Corridor*, prepared for the Indiana Department of Transportation, March 1996.

The Urban Institute and Cambridge Systematics, Inc., *Final Report: Public Transportation Renewal as an Investment: The Economic Impacts of SEPTA on the Regional and State Economy*, prepared for the Delaware Valley Regional Planning Commission, June 1991.

Weisbrod, G.E. and J. Beckwith, "Measuring Economic Development Benefits for Highway Decision-Making: The Wisconsin Case," *Transportation Quarterly*, Volume 46, Number 1, January 1992.

Method: Benefit-Cost Analysis

Description

Many of the potential economic benefits of a transit investment stem from reductions in travel times (for passengers and/or freight), which are determined by using travel demand models described in the last section. The reduction in travel time and other improvements in the transportation system's performance (i.e., safety benefits and changes in transportation operating costs) are assigned monetary values (i.e., cost savings). These cost savings represent direct user benefits, and historically comprise the numerator of the benefit-cost equation. Thus, the outputs from the travel demand models are the direct inputs to benefit-cost analysis. Several recent studies have used these benefits as an input into economic simulation and forecasting models to compute additional indirect benefits. (Forecasting models and the use of user benefits as inputs to these models are discussed later).

In a free market situation, the monetary value of travel time will reflect the value of mobility and access for all sectors of the economy. The more valuable accessibility and mobility, the higher the price of travel (i.e., the non-travel benefits that accessibility and mobility provide will be capitalized into the price of travel). Hence, if the value of travel time is modeled accurately, travel time savings benefits (measured in dollars) stemming from a transportation improvement will be a measure of many of the benefits that accrue.

A benefit-cost ratio can be calculated by dividing the stream of benefits over a period of time by the project costs (including construction, operating, and maintenance costs). The streams of benefits and costs must be discounted with an appropriate discount rate to account for the time value of money. A benefit-cost ratio greater than one indicates that the project's benefits outweigh the costs, although, in most cases, decision-makers are only comfortable with ratios somewhat higher than one due to the uncertainty associated with predicting the future.

The basic steps and key inputs to benefit-cost analysis include:

1. **Defining the economic life of the project.** Transit investments typically take between 20 and 30 years for the full range of impacts – especially changes in land use – to take full effect. In addition, benefits and costs more than 30 years in the future that are discounted to a present value are so small as to become inconsequential.

2. **Choosing a discount rate.** The rate should reflect society's time value of money. For transit projects in developed countries such as the United States, values normally range between 12 and 14 percent.

3. **Measuring benefits.** The most significant benefit of transit investments is usually travel time savings that accrue over the life of the project. These savings are monetized by multiplying them by a dollar value of time. Other significant benefits of transit investment include reduced accidents (i.e., fatalities, injuries, and property damage) and reduced air pollution.

   Estimating consumer surplus measures the monetary equivalents of travel time savings and reduced accidents. In basic terms, consumer surplus is composed of the benefits of at least three groups:

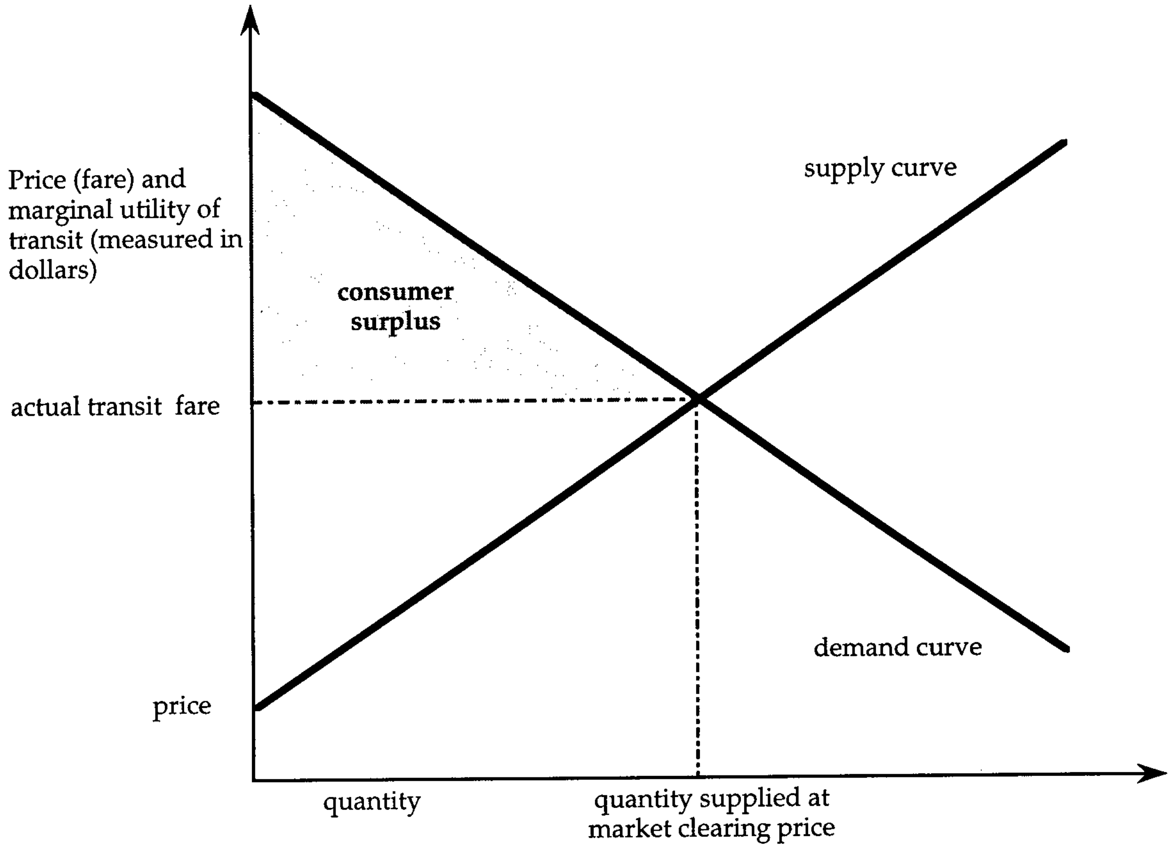
   a) The sum of the maximum fare each transit rider would be willing to pay (regardless of the single, actual fare); plus,

   b) The value that auto drivers and truckers derive from the free flow of road traffic created by transit riders not driving; plus,

   c) The value of having transit available to those people who neither ride transit nor drive but enjoy knowing such mobility is available if and when they need it (i.e., option or backup value).

   Figure 4.1 shows that all riders pay the same fare but many of these riders would be willing to pay more. If the additional amount that each rider were willing to pay is added together, the total equals the consumer surplus defined by the shaded triangle. The consumer surplus for transit is the sum of the consumer surpluses for the three groups described above.

Figure 4.1 Consumer Surplus for Transit Riders



The methods of calculating consumer surplus are very complex and often disputed. Nevertheless, most experts believe the Small-Rosen Log-Sum Method to be the most comprehensive method, yet avoids double-counting. Small-Rosen simultaneously takes account of benefits from new transit service and improvement in competing modes.

4. **Calculating the benefit-cost ratio.** Benefits and costs are estimated for each year over the economic life of the project and discounted to a present value. The algebraic formula has the following form:

$$\sum_{i=1}^{n}\sum_{j=1}^{k} v_{ij}(1+r)^{-n} = v_{11}(1+r)^{-1} + v_{21}(1+r)^{-2} + v_{n1}(1+r)^{-n}\ldots$$
$$+v_{12}(1+r)^{-1} + v_{22}(1+r)^{-2}+\ldots+v_{n2}(1+r)^{-n}+\ldots$$
$$+v_{1k}(1+r)^{-n} + v_{2k}(1+r)^{-n}+\ldots+v_{nk}(1+r)^{-n}$$

$$C = K + OM(1+r)^{-n}$$

$$\frac{B}{C} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{k} v_{ij}(1+r)^{-n}}{C}$$

where:

B = present value of the stream of benefits
C = present value of the stream of all costs
K = construction costs in the base year
v = estimated value in each year
OM =operating and maintenance expenses
n = economic (service) life of the investment
r = discount rate
k = type of economic benefit (e.g., travel time savings, accident reductions, air pollution reductions, etc.)

When to Use

Benefit-cost analysis is used to make an overall assessment of the social value of a project. The technique frequently is used in MISs and EISs to evaluate the economic value of a transit investment compared to alternatives, including a no-project base case.

Impacts Measured

Benefit-cost analysis converts travel time savings, reductions in accidents, changes in operating costs, decreased air pollution, land conservation, ecological habitat preservation, etc., into dollar values to monetize the benefits of a transportation investment. The dollar value of benefits is then compared to costs in a benefit-cost ratio.

Advantages

Benefit-cost analysis is a widely accepted method for evaluating the economic impact of transportation projects. It is the best tool available to determine if society will be better off economically, setting aside all political considerations. Benefit-cost analyses make use of output from travel demand models, to forecast cost changes (measured in terms of travel time savings, safety benefits, and changes in operating costs) resulting from a transportation investment. If such models are available, travel-time-based benefits assessments are relatively easy and inexpensive to conduct by applying accepted values for each type of cost, and multiplying by the savings provided by the project. The technique has been well developed for both transit and other transportation investment types, allowing for easy comparison between modal alternatives.

Disadvantages

Benefit-cost analysis can be easily misused to overstate the benefits associated with a transit investment. Tallying redistributive impacts in a benefit-cost calculus would amount to double-counting, since redistributive impacts do not represent net economic growth. Nevertheless, travel time savings, improved accessibility, reduced congestion, and other impacts of transportation improvements also get capitalized into land values. These secondary impacts are generative: they occur over and above the direct benefits that accrue to users of the transportation system. It is, therefore, appropriate to include them in benefit-cost analyses. The analyst must be diligent to ensure that only the generative impacts are included in the benefit-cost ratio.

Benefit-cost analysis is particularly sensitive to changes in the discount rate used to calculate the value of costs and benefits over time, as well as to the analysis period used for the investment scenario. This sensitivity is a major disadvantage of this method for transit projects. Benefits of transit involve long-term structural changes and adjustments, such as more compact land development, energy conservation, etc., which accrue over the long term (i.e., two decades or more after the initial transit investment). Discounting these benefits yields very small present values, whereas the large construction costs are borne up front and are not discounted significantly. Uncertainty and risk drive up the discount rates, thus depressing the cumulative benefits of transit investment. Thus, small variations can turn a positive impact into a negative impact or vice versa.[16] Even at low discount rates, benefit-cost analysis is biased against the long-term benefits of transit and will tend to favor highway investment, which has more short-term benefits.

Benefit-cost analysis requires the use of a transportation network model to estimate travel time savings. While the calculation of the benefit-cost ratio is not complicated, the development and use of a transportation network model requires substantial technical skill.

Data Sources

Benefit-cost analysis for transportation projects depends on output from a transportation network model. The transportation model is used to identify travel time savings, accident reductions, and changes in operating speeds. These data form the basis for the benefit-cost analysis. Factors for converting these data to monetary terms may come from several sources. Many states (and some metropolitan planning organizations) have adopted

[16] Acceptable discount rates, analysis periods, and values for travel time and safety benefits are often established on a state-by-state basis, and must be appropriate to the geographic area under study.

standard values for travel time savings for work and non-work trips. Many state DOTs also have adopted standard values for accidents, broken down for accidents involving property damage, personal injuries, and deaths, as well as estimates of operating costs as a function of posted speed and operating speed.[17] It is advisable to check with state and local agencies to determine whether or not such factors exist so that the benefit-cost analysis is consistent with other studies in the same state.

Other data sources for monetary values for travel time, safety benefits, and operating costs are the HERS and STEAM models, developed for the Federal Highway Administration.[18] These models have developed standard values for in-vehicle travel time, and for accident costs on a per vehicle-mile basis. Construction and operating costs for the transit system should be developed as part of the engineering process.

Example: Benefit-Cost Analysis of Portland's Westside LRT Extension: A Benefit-Cost Analysis (BCA) was carried out for the proposed Westside Light Rail Transit (LRT) extension in Portland. Cumulative benefits were measured over a 30-year operational timeframe, set at 1995-2025. Estimated cumulative benefits were discounted to their 1988 "present worth" and compared to capital outlays as well as 30 years of estimated annual operating and maintenance costs, also discounted to 1988 dollars.

The analysis focused on comparing user benefits to costs. Thus, potential external and non-user benefits, such as air quality improvements, were not accounted for. Decision-makers reasoned that if user benefits can be shown to greatly exceed costs, then there is all the more reason to proceed with the investment since adding non-user benefits would only increase the BCA ratio. The following user benefits were estimated:

- Travel time savings: using output from urban transportation planning forecast models and setting assumed values of time, the monetary value of travel time savings was estimated for four groups: 1) transit users who switch from automobile travel; 2) transit users who previously rode another form of transit; 3) motorists experiencing less traffic congestion; and 4) truckers and other goods movement carriers experiencing less traffic congestion.
- Operating cost savings: motorists riding LRT will avoid variable costs of operating an automobile, such as gasoline, oil, and taxes.

[17] These values are derived from shadow prices estimated based on the investments made to reduce deaths and injuries (e.g., air bags, Jersey barriers, guard rails, etc.). See, for example, the New York State Department of Transportation Highway User Cost Accounting Micro-Computer Package.

[18] Federal Highway Administration, *The Highway Economic Requirements System Task D: Documentation of Model Structure*, January 1990.

- Parking cost savings: reduced downtown parking outlays.
- Insurance cost savings: reduced insurance surcharge for the work trip use of automobiles.
- Additional vehicle savings: reduced expenditures for a second or third car.
- Infrastructure cost savings: foregone expenditures for additional highway improvements.

For example, the monetary value of travel time savings to transit users who switch from automobile travel was estimated using the following formula:

$$\text{Benefit} = \left(S_w \times \frac{V_w}{60} \times A_w \right) + \left(S_{nw} \times \frac{V_{nw}}{60} \times A_{nw} \right) \quad (1)$$

Where:

S_w = Daily time savings of home-based work trips diverted to LRT, in minutes;

V_w= Value of time for work trips, in dollars per hour;

S_{nw}= Daily time savings of non-work trips diverted to LRT, in minutes;

V_{nw}= Value of time for non-work trips, in dollars per hour;

A_w= Annual conversion factor (workdays in a year);

A_{nw}= Annual conversion factor (average days of non-work travel in a year).

The following inputs and sources were used in deriving estimates:

S_w = -108,581 minutes, based on regional travel demand forecasting model outputs, with LRT versus without LRT;

V_w = $4.00, based on one-half the estimated mean prevailing wage rate;

S_{nw}= -32,835 minutes, based on regional travel demand forecasting model outputs, with LRT versus without LRT;

V_{nw} =$2.00, assumed at one-half the value of V_w;

A_w = 250 days;

A_{nw} =300 days.

Inputting these values into equation 1 yielded the following estimate:

$$\text{Benefit} = \left[(-108{,}581) \times \frac{\$4.00}{60} \times 250\right] + \left[(-32{,}835) \times \frac{\$2.00}{60} \times 300\right]$$

Benefit = -\$2.138 million

Thus, because motorists switching from automobile to LRT travel will, on average, increase their travel times, there is a "negative benefit," or net cost, of over \$2.1 million dollars per year (in 1988 dollars).

A much larger travel time savings benefit can be expected to accrue to those who continue to drive to work and experience less congestion along LRT-served corridors. It is assumed that this benefit would accrue only to those making work trips. Based on network outputs from Portland's regional travel demand forecasting model, it was estimated that the Westside extension would save those who continue to commute by automobile 149,081 minutes per workday (i.e., Sw = 149,081). Applying this figure to equation 1 yields the following estimated annual travel time savings benefits to automobile commuters:

$$\text{Benefit} = \left[149{,}081 \times \left(\frac{\$4.00}{60}\right) \times 250\right] = \$2.485 \text{ million}$$

The complete estimated user and transportation system benefits of the Westside LRT extension are presented in the following table. Overall, the investment would generate almost \$700 million in estimated total transportation user and infrastructure cost savings. This compares to estimated capital and cumulative operating and maintenance costs over the 30-year service life, discounted to 1988 currency, of approximately \$300 million. The benefit-cost ratio was thus:

$$\text{B/C ratio: } \frac{\$696.172 \text{ million}}{\$300 \text{ million}} = 2.33$$

This estimate suggested that the Westside LRT extension would produce sufficient benefits to well offset its costs. The largest benefits would come from: 1) highway costs savings at around \$524 million annually; 2) parking costs savings of diverted motorists at approximately \$109 million; and 3) second-car ownership savings (exclusive of insurance) of some \$42 million. It was because of these estimated gains in public welfare that Portland policy makers opted to construct the Westside LRT line.

Table 4.2 User and Transportation System Benefits of Westside LRT Extension ***(All Values Expressed in Millions of 1988 Dollars)***

	Annual[1]	**Cumulative**[2]	**Present Worth**
Category:			
1. Time Savings:			
a. Diverted motorist	$ -2.138	$-64.140	$ -25.656
b. Transit users	0.728	21.840	8.736
c. Continuing automobile commuters	2.485	74.550	29.820
d. Goods movement	0.115	3.450	1.380
2. Operating Cost Savings:	0.280	8.400	3.360
3. Parking Cost Savings:	9.084	272.520	109.008
4. Insurance Cost Savings:	0.306	9.180	3.672
5. Second-Car Ownership Savings:	3.471	104.130	41.652
6. Infrastructure Cost Savings:	--	--	524.200
TOTAL BENEFIT:			**$696.172**

[1] Annual calculations set for the year 2005, at the time an estimated 10 years following the planned opening of the Westside LRT.

[2] Over the entire 1995-2025 service life of the project.

Source: Robert J. Harmon & Associates, Inc., Westside LRT MAX Extension: *User Benefit-Cost Analysis*, Portland, 1988.

Complementary Methods

Benefit-cost analysis requires the use of a transportation network model to calculate reductions in travel times, operating costs, and accident rates. The user benefits calculated for benefit-cost analysis can be used in an economic forecasting and simulation model to estimate the direct, indirect, and induced economic impacts of the user benefits and costs over time in terms of employment, income, output, and sales impacts of the benefits and costs of a transportation investment.

Benefit-cost analysis may not be readily applied to some smaller or idiosyncratic transit investments or when monetizing of benefits is problematic. Cost-effectiveness measures provide alternatives to benefit-cost analysis. Rather than measuring benefits and accepting the possibilities of error propagation, mismeasurement, etc., costs are indexed to output measures that are thought to be closely associated with monetized benefits. These service consumption measures include passenger trips, seat-miles of travel, cost per rider, cost per person-mile traveled divided by VMT, and cost per additional transit trip generated. These measures demonstrate an investment's efficient use of limited funding relative to the next best alternative in the short term. Thus, cost-effectiveness indicators are used to guide short-term service planning, management, and operations (i.e., a five-year transit plan), given a fixed, sunk investment.

Cost-effectiveness does not measure economic impact directly, nor can it be used as an input to economic impact analysis. It can on occasion give opposite results. A transit investment that receives significant federal funding or uses a high percentage of regionally produced inputs, for example, could generate positive economic impacts. Nonetheless, it could still be the least cost-effective alternative when compared to a roadway investment funded largely with local tax money or one that employs labor and/or materials imported into the region.

Method's Score Card

The following score card grades the performance of benefit-cost analysis according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity		✓	
External Validity		✓	
Reliability		✓	
Minimal Data and Resources	✓		
Transparency		✓	

Selected References

Cambridge Systematics, Inc., *Final Report: Investment in Public Transportation: The Economic Impacts of the RTA System on the Regional and State Economies* (Project A2077), prepared for the Chicago RTA, January 1995.

Cambridge Systematics, Inc., *Economic Impacts of the Southwest Indiana Highway Corridor*, prepared for the Indiana Department of Transportation, March 1996.

The Urban Institute and Cambridge Systematics, Inc., *Final Report: Public Transportation Renewal as an Investment: The Economic Impacts of SEPTA on the Regional and State Economy*, prepared for the Delaware Valley Regional Planning Commission, June 1991.

Weisbrod, G.E. and J. Beckwith, "Measuring Economic Development Benefits for Highway Decision-Making: The Wisconsin Case," *Transportation Quarterly*, Volume 46, Number 1, January 1992.

Method: Input-Output Models

Description

Input-output (I-O) modeling is used to enumerate inter-industry production and linkages that occur as a consequence of increased demand and consumption within a particular sector, such as transit. An I-O model is a matrix, wherein each row and column represents a different industry or industrial segment. The cells of the matrix describe, mathematically, the production-consumption relationships between the various industries and segments. I-O models typically use regression equations to associate purchases of goods or services in one industry with similar purchases in other sectors. Transit facility construction, for example, would create increased production, consumption, and employment in the fabricated metals and stone/glass/clay industries, two industries that are suppliers to the construction industry.

Inputs into the model include the dollar amount spent in different industries to construct, operate, and maintain a new transit system. The model estimates the dollar value of direct, indirect, and induced production by industry resulting from the spending. I-O models also can trace the effects of travel cost reductions as they ripple through the regional economy. In this kind of analysis, the input to the model is the dollar value of the travel costs savings (which are derived from estimates of travel time savings, safety benefits, and changes in operating costs) for industries that will benefit from a transportation investment.

When to Use

I-O models are used to measure transfer impacts associated with the construction of a transit investment. They are frequently employed to measure impacts reported in MISs and EISs, and are used to compare alternative investments and financing scenarios.

Impacts Measured

I-O models measure transfer impacts, usually in terms of employment and income. They also provide inter-industry outputs by industry sector.

Advantages

I-O modeling is a widely accepted methodology for tracking the economic impacts of major investments within a regional economy's industry sectors. There are several widely available models on the market, including the RIMS-II model developed by the federal government, the PC-IO model, and IMPLAN. They often are available at a low cost. (Multipliers from the RIMS-II model generally are available at the statewide level for a few thousand dollars.)

Disadvantages

Some level of expertise is required to use an I-O model and interpret the model's results. I-O models are regional in scale. The models cannot predict impacts on individual neighborhoods or station areas, where many of the redistributive impacts of transit investments may occur. The regional scale of I-O models largely stems from the fact that many of the industry data that form the inputs to the models are regional (e.g., county-level or above). Many are obtained from U.S. Department of Commerce, Bureau of Labor Statistics data, which are based on broad interregional economic expansion trends.

Because I-O models focus only on the interactions of industries or industrial segments, they exclude other, potentially significant economic impacts. For example, if a transit investment reduced average household travel and vehicle ownership costs, consumers would have additional disposable income, and would return some of that income back to the regional economy in the form of increased spending. Since I-O models do not simulate the behavior of individuals or households, they do not account for these kinds of benefits.

Another limitation of I-O models is that they are static. They do not account for long-term economic, industrial, and demographic changes, or for changes in business costs over time. Consequently, I-O models produce results that are only valid for fixed points in time. Furthermore, many of the I-O models in use today were developed several years ago. Thus, they do not reflect up-to-date inter-industry relationships. Therefore, when multipliers from old models are applied to current projects, they may not provide accurate results.

Finally, it can be difficult to find models relevant for a specific region. Many researchers rely on state-level models, but these models may not appropriately reflect the unique inter-industry relationships for a given region. This is especially true for large, diverse states with very distinct regional economies.

Data Sources

Because the development of I-O models is very time-consuming, it is unlikely that a new model will be developed specifically for a transit project. In general, analysts either purchase commercially available models, or contract with universities that have developed I-O models for specific states or regions. The most commonly used commercial (and quasi-commercial) models include IMPLAN, the PC-IO model of the Regional Science Research Institute, and the RIMS-II model (available from the U.S. Bureau of Economic Analysis).[19]

Example **Input-Output Modeling of Alternative Transit Financing Approaches in Portland:** I-O models were developed and used to explore the likely regional economic effects of alternative financing packages for expanding transit services in the Portland metropolitan area. The Portland I-O model traced changes in sector output that could be expected from transferring resources from private, non-transit to public transit operations. The basic question posed was: "what would be the net economic impact of a $1 million increase in transit operating assistance generated by each of seven financing options, and how would this impact be distributed across sectors of the regional economy?" The direct losses associated with alternative taxes were defined in terms of the reduction in sectoral final demands that would follow the imposition of taxes. The IMPLAN model was used in making *ex ante* estimates.

The central question raised was whether the effects of a reduction in disposable income would be offset by welfare gains from the transit operator's disposition of the subsidy. One of the finance options studied was a gasoline tax. Assuming a price elasticity of -0.2, it was found that a tax rate of 0.17 percent would be needed to generate $1 million in revenues. Adjustments were made for the reduction in demand resulting from the tax. Reductions in gasoline consumption in turn will trigger reductions in the direct demand for other products consumed in the operation of automobiles: repairs and maintenance, tires, oil, accessories, and parking, to name a few.

Table 4.3 shows the estimated net change in final demand for the seven alternative financing schemes. Gasoline taxes, for example, would reduce the demand for sectors that provide inputs to automobile consumption at approximately $50,000 for every $1 million collected through gasoline taxes. The biggest loss would be in the petroleum and chemical products sectors.

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19 • The IMPLAN model, MIG Inc., 1940 South Greeley St., Suite 101, Stillwater, Minnesota 55082-6059, Contact: Doug Olsen, (612) 439-4421. E-mail: implan@mig-inc.com, Home Page: www.IMPLAN.com;

• PC-IO model of Regional Science Research Corporation, P.O. Box 3209, Hightstown, New Jersey 08520, Contact: Ben Steven (609) 448-6966; and

• The RIMS-II model is available from the U.S. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, D.C. 20230, Contact: Zoe Ambargis, (202) 606-5343, E-mail: RIMSREAD@BEA.DOC.GOV, Home Page: www.bea.doc.gov/bea/rims/rims-1.htm.

Table 4.3 Net Change in Final Consumption Demands Across Different Industrial Sectors of the Greater Portland Economy, Estimated Under Seven Alternative Financing Scenarios

Sector	Gasoline Tax ($)	Property Tax ($)	Income Tax ($)	Parking Tax ($)	Sales Tax ($)	Payroll Tax ($)	Fare Increase ($)
Agriculture/Forestry/Fisheries	-295	-822	-3,235	-625	-7,908	3,628	-8,495
Mining and Quarrying	0	-5	0	0	0	-451	0
Contract Construction	0	-8,500	0	0	0	-46,100	0
Food and Kindred Products	-2,678	-11,135	-28,194	-5,544	-102,503	-17,453	-73,840
Textiles and Apparel	824	6	-3,772	308	-158,646	5,273	-11,995
Wood Products	253	-3,025	-3,058	-568	-17,903	-4,866	-8,076
Pulp and Paper Products	7,287	3,880	4,515	6,975	5,434	734	-442
Petroleum and Chemical Products	-105,564	53,605	49,966	54,286	61,976	61,022	191,704
Rubber and Leather Products	1,192	10,403	10,094	10,604	11,512	10,810	25,843
Stone, Clay, and Glass Products	-3	-114	-273	-33	394	158	-757
Primary and Fabricated Metal Products	1,097	-5,504	285	1,005	-9,472	-28,473	-1,166
Machinery	-52	-2,621	-357	-87	-16,536	-17,066	-901
Electrical Equipment and Instruments	34,964	30,017	32,192	34,652	39,031	9,741	27,235
Transportation Equipment	-84,332	-4,434	-7,005	-1,365	-106,418	-7,706	129,864
Miscellaneous Manufactured Products	-121	-399	-1,439	-269	1,814	1,068	-3,796
TCU	34,590	-4,620	15,394	32,434	-39,997	-165	-18,946
Electrical Services	6,544	2,277	-654	5,736	17,110	15,484	-13,532
Wholesale-Retail Trade	-47,251	-75,891	-55,892	11,608	2,321	-206,842	-108,067
FIRE	78,566	-10,714	-3,931	69,299	198,480	-21,652	-151,509
Services	24,656	-17,232	-42,682	-264,022	-17,745	21,693	-163,534
Local Government Enterprises	1,393	533	-3,406	854	8,437	8,172	-11,991
Federal Electric Utilities	-52	-141	-357	-87	394	324	-901
State and Local Electric Utilities	-119	-302	-1,166	-236	1,419	1,382	-3,041
Scrap	-77	-224	-990	-180	1,262	1,262	-2,622
Households	-83	-317	-1,535	-246	2,050	2,050	-4,136
Total	**-49,768**	**-45,281**	**-45,500**	**-45,500**	**-45,500**	**-173,067**	**-213,101**

Changes in final demand were then translated into changes in output levels of different sectors. Table 4.4 presents the direct and indirect changes in net output resulting from the seven financing options.

Table 4.4 Net Change in Industrial Outputs Across Different Sectors in the Greater Portland Economy, Estimated Under Seven Alternative Financing Scenarios

Sector	Gasoline Tax ($)	Property Tax ($)	Income Tax ($)	Parking Tax ($)	Sales Tax ($)	Payroll Tax ($)	Fare Increase ($)
Agriculture/Forestry/Fisheries	-731	-3,483	-8,035	-4,081	-23,148	2,453	22,528
Mining and Quarrying	-135	8	35	72	37	-607	141
Contract Construction	4,131	-10,051	-1,533	942	11,676	-49,060	-15,365
Food and Kindred Products	-3,152	-15,480	-35,797	-22,203	-119,623	13,642	-98,673
Textiles and Apparel	787	-122	-5,220	-323	-210,412	6,315	-16,488
Wood Products	-3,047	-5,282	-4,767	-957	-29,369	-13,074	-9,615
Pulp and Paper Products	6,615	2,838	2,688	5,580	-188	-4,618	-10,273
Petroleum and Chemical Products	118,733	60,019	55,848	60,085	64,475	65,152	212,368
Rubber and Leather Products	681	10,831	10,357	10,581	10,266	10,738	26,574
Stone, Clay, and Glass Products	-1,246	-411	-553	-128	-1,517	-1,851	-938
Primary and Fabricated Metal Products	-9,157	-6,914	-502	1,340	-29,349	-40,399	10,673
Machinery	-2,139	-2,774	-363	-615	-20,582	-19,497	1,900
Electrical Equipment and Instruments	36,844	32,247	34,641	35,365	39,935	8,223	29,573
Transportation Equipment	-89,567	-5,688	-8,659	-6,166	-114,492	-10,061	133,379
Miscellaneous Manufactured Products	-199	-533	-1,618	-753	1,432	608	-4,472
TCU	-32,550	-9,058	13,043	29,120	35,792	-15,199	-36,930
Electrical Services	5,337	792	-2,577	3,289	16,019	11,403	-20,701
Wholesale-Retail Trade	-54,039	-84,606	-64,944	-7,301	-26,839	-234,510	-136,675
FIRE	-85,513	-25,303	-17,353	49,135	210,099	-62,509	-221,995
Services	21,894	-31,707	-56,389	-295,104	-29,432	-22,870	-221,285
Local Government Enterprises	1,718	-557	-4,403	-937	8,791	5,117	-17,111
Federal Electric Utilities	-110	-193	-429	-178	345	176	-1,163
State and Local Electric Utilities	-262	-485	-1,394	-563	1,255	867	-3,898
Scrap	-341	-401	-1,012	-267	275	4	-2,512
Total	**-86,789**	**-96,314**	**-98,938**	**-144,785**	**-204,554**	**-349,555**	**-426,017**
Household Income	-14,660	-45,342	-42,297	-85,247	-68,761	-139,166	-160,480
Percent of Total Net Change	16.9	47.1	42.8	58.9	33.6	39.8	37.7
Multiplier	1.744	2.127	2.174	3.182	4.496	2.020	1.999

The range of total impacts is considerable – from a net reduction of $87,000 associated with the gasoline tax to a loss of $426,000 were a fare increase introduced. The direct losses associated with the gasoline taxes are heavily concentrated in the petroleum and FIRE sectors, whose multipliers (i.e., degree of ripple effect) are among the smallest in the models. The direct gains from the gasoline tax are concentrated in the electrical equipment, services, and pulp and paper sectors, whose multipliers are relatively large. Overall, gasoline taxes would induce the smallest losses in economic outputs among industrial sectors in the Portland region – $86,800 per million dollars in gasoline taxes. The costs to households from the gasoline tax (defined as the real cost of the tax minus the savings from the reduction in travel cost) would also likely be the lowest among the options – $14,700 per million dollars in gasoline tax payments. The overall conclusion of this analysis was that the Portland region would be better off keeping the money in the private sector rather than taxing consumption, and indirectly production, for the sake of underwriting the costs of transit operations.

Complementary Methods

I-O models are frequently used by themselves to estimate the impacts of construction, operating, and maintenance costs of transportation investments. To forecast multiplier impacts other than those associated with construction, maintenance, and operations, practitioners must employ expert opinion, economic base modeling, interviews with businesses, or another method to identify those industries likely to realize long-term benefits from the transit investment. An I-O model can be applied in conjunction with a transportation network model to quantify the broad regional economic impacts of user benefits derived from a transit investment. Forecasting and simulation models (which are discussed separately below) incorporate the inter-industry production-consumption functions of I-O models.

Method's Score Card

The following score card grades the performance of I-O models according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity			✓
External Validity	✓		
Reliability		✓	
Minimal Data and Resources	✓		
Transparency	✓		

Selected References

Forkenbrock, D. and N. Foster, "Economic Benefits of a Corridor Highway Investment," *Transportation Research* 24A, 4:301-312, 1990.

Parsons Brinckerhoff Quade and Douglas, Inc., Cambridge Systematics, Inc., and Regional Science Research Institute, *Summary Report: CONEG High Speed Rail Regional Benefits Study: A Report on the Benefits to the Region of Improved Passenger Rail Service Between Boston and New York,* prepared for the Coalition of Northeastern Governors High Speed Rail Task Force, October 1990.

Strathman, J., *Effects of Banfield Transitway Expenditures on the Portland Metropolitan Economy,* Center for Urban Studies, Portland State University, Portland, Oregon, 1983.

Strathman, J. and K. Dueker, "Regional Economic Impacts of Local Transit Financing Alternatives: Input-Output Results for Portland," *Transportation Research Record* 1116, pages 40-48, 1987.

Method: Economic Forecasting and Simulation Models

Description

Economic forecasting and simulation models contain the inter-industry production-consumption functions of I-O models, but add to them additional elements. Forecasting and simulation models can account for factors such as business cost, competitiveness, the shifting mix of population, and business characteristics. They also differentiate between the short-term impacts of constructing a transportation investment and the long-term impacts of maintaining and operating it, and the growth and expansion of user benefits over time. In addition, certain models are designed to simulate the behavior of individuals in response to changes in transportation costs, land prices, and other factors. Such models come much closer than I-O models to capturing the full range of potential benefits from transportation investments. They include systems of regression equations that are simultaneously estimated, stochastic simulation (also called Monte Carlo simulation), stepwise regression, and other statistical models. Normally, variables such as demand levels, capital supplies, service levels, and prices simultaneously influence each other. Simulations attempt to replicate these simultaneous relationships. Estimated equations are used to generate forecasts.

When to Use

Forecasting and simulation models primarily are used for predictive studies. It is particularly useful when the goal of the analysis is to compare alternatives, measure the regional economic (development) impacts of a project, or secure public financing.

Impacts Measured

These models estimate generative impacts measured in a variety of ways, including employment, output, sales, and productivity by industry sector, and personal income. Some models also predict changes in labor costs and taxes.

Advantages

These models forecast both construction period impacts and long-term, permanent impacts. For example, the REMI model can use inputs for travel time savings, apportioned to specific industries, to predict changes in business output, sales, gross regional product, employment, and population 30 years into the future. This is a very powerful tool for understanding long-term economic impacts. Because so many of the economic benefits associated with a transit system lag many years after construction is completed, it is important for researchers to be able to evaluate investments for several years into the future. Finally, they do not require substantial computer time to run.

Disadvantages

Forecasting and simulation models tend to be costly (often $15,000 to $20,000 just to purchase the model) and require substantial economic expertise on the part of the analyst in order to identify the appropriate inputs and interpret the results. These models can be run on personal commuters, but require substantial disk space. Acquisition of data inputs can be time-consuming.

Forecasting and simulation models rarely predict impacts below the county level (because much of the data used to construct the models is aggregated to the county level). Some can, however, be used to identify inter-county shifts within a metropolitan area.

Data Sources

The REMI Regional Economic Forecasting and Simulation Model and the DRI Economic Forecasting Model are the two most common models in use in the United States. Analysts using these models can input a wide range of data, including monetized benefits and costs developed for a benefit-cost analysis, construction costs by type of expenditure, construction employment, derived employment multipliers from an I-O model, and operating costs, to identify how these factors influence regional economic changes.

Example

Economic Simulation Models: In 1991, an analysis was conducted by The Urban Institute and Cambridge Systematics, Inc. of the economic impacts of transit investment in the Philadelphia region. *Public Transportation Renewal as an Investment: The Economic Impacts of SEPTA on the Regional and State Economy* was a comprehensive study, which established whether expenditures by the state and local governments for rehabilitation and reinvestment in the existing transit system could provide enough economic benefits to justify the expenditures. The study evaluated the impacts of SEPTA's services and proposed capital investments on transportation costs and on the overall economy of the Philadelphia metropolitan area, the State of Pennsylvania as a whole, and the rest of Pennsylvania outside the metropolitan area. This study indicated whether transit rehabilitation programs "pay off" as investments, and thus justify expenditures by state and local governments.

An important aspect of this study is that it is comprehensive in terms of estimating how alternative levels of investment in SEPTA would affect travel times and travel costs for individual travelers, and how those changes would end up affecting the cost of doing business, individual spending patterns, and the economy of the region and the State of Pennsylvania. The study made extensive use of a single county and eight-county 52 sector REMI models.

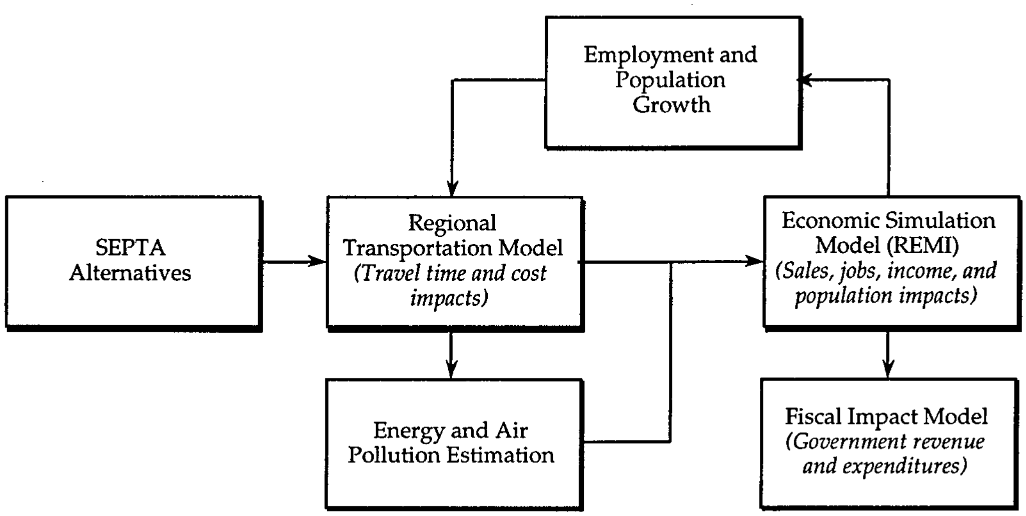
The four alternative courses of action ranged from an immediate permanent shutdown of all SEPTA services to a rehabilitation costing $4.5 billion in capital expenditures over 10 years, including contingencies and inflation or $450 million per year. The gradual or immediate elimination of SEPTA would involve no capital program expenditures. The partial reduction would involve about half the level of capital expenditures per year as would rehabilitating all of SEPTA.

Each of these alternatives was quantitatively defined in terms of annual SEPTA ridership, revenues, capital costs, and operating costs. The consequent impacts on highway costs, the economy, and other social concerns were then assessed through an integrated set of economic models, augmented by interviews with key leaders of businesses and social service agencies. The analysis process involved six steps:

1. Evaluation of future scenarios in terms of transit and road capacity and service levels,
2. A transportation analysis model to forecast impacts on regional transportation costs,
3. An economic analysis model (REMI) to forecast impacts on metropolitan and state economic growth,
4. A fiscal model to forecast impacts on government finance,
5. Energy consumption and air pollution estimation processes, and
6. Interviews with businesses, economic development professionals, and representatives of affected population groups.

Figure 4.2 shows the overall structure of the analysis and the position that the REMI simulation models played.

Figure 4.2 Structure of the Analysis Process



The magnitude of economic impacts was estimated using a regional economic simulation model. The REMI forecasting and simulation model, developed by Regional Economic Models, Inc., was specifically calibrated for two regions: 1) the eight-county Philadelphia metropolitan area, and 2) the State of Pennsylvania excluding the Philadelphia area.

The REMI model system is a nationally renowned economic simulation and forecasting system specifically designed for policy analysis. Developed by Dr. George Treyz of the University of Massachusetts-Amherst, it is a highly sophisticated computer model system, the result of over 10 years of development. It has been documented and reviewed in a variety of professional journals. Key aspects of the REMI simulation model are its sensitivity to factors such as population migration, effects of business operating costs on the location of industry, detailed changes in wages by occupation, business mix shifts, technological changes, and inter-industry trade flows.

The REMI forecasting and simulation model includes all of the inter-industry interactions among 49 private sectors in the economy. It also includes the trading flows by industry between the Philadelphia metro area and the rest of the state of Pennsylvania.

In addition to containing a complete inter-industry and trade flow structure, the model also includes key aspects of the economy that are regarded as important for policy evaluation. These include the effect on the location of industry, in the present and future, of changes in the relative cost of doing business. This relative cost of doing business is built up for each industry based on tax costs, fuel costs, wage costs, and costs of all the intermediate inputs in the area. The model allows for substitution among capital, labor, and fuel, based on shifts in relative cost in these factor inputs. It has a wage determination response for each of 94 occupations based on shifts in relative demand for labor in each occupational category. These wage changes, by occupation, affect costs for each industry. The model includes a migration response to employment conditions in the area.

The model is calibrated specifically to the study areas. This calibration starts with the detailed analysis of the economy at the level of 500 separate industries. At that level, the proportion of local use supplied locally for each industry is estimated using results from quantitative work done across all states and state-specific adjustments derived from direct observation in the Census of Transportation.

The model makes a forecast for over 2,000 variables (including Gross Regional Product by final demand sectors and by industries and employment and cost of doing business for 53 industries) with a complete history or forecast for all of these variables from 1969 through 2035. Using any of over 700 policy variables it is possible to introduce changes that the region may experience due to policy initiatives.

Overall impacts on the State of Pennsylvania are estimated by adding together impacts on the Philadelphia metropolitan area and impacts on the rest of the state, and then subtracting a portion of the Philadelphia area impact which is attributable to the three New Jersey counties. Since SEPTA services are essentially limited to the Pennsylvania part of the metropolitan area, impacts on New Jersey residents and workers would be limited. New Jersey residents would be primarily affected when commuting to/from Philadelphia, where travelers would be affected by increased road congestion and loss of public transit services.

The modeling and analysis process is dynamic: transportation cost impacts and overall economic impacts for each scenario are modeled year by year. The transportation model estimates transportation-related costs for each year. These are used in the economic model to estimate changes in economic activity over the year. The change in economic activity is then input to the transportation model for the next year, and this analysis process is carried on through the year 2020 in order to estimate long-term changes.

The changes in business sales, employment, personal income, and population at the metropolitan and statewide levels are predicted by the economic model. These changes will, in turn, affect revenues and expenditures for local governments and state governments. Specifically, the decreases in business sales, employment, and income will bring proportional reductions in some sources of government revenue. The decreases in employment and population will also bring reductions in demand for services, but government expenditures will not necessarily be reduced proportionally to the change in demand, as there are some fixed costs of maintaining existing facilities.

Benefit-cost analysis was used to assess the net public benefits of the SEPTA reduction alternatives, relative to the base case of rehabilitating and continuing to operate SEPTA. It compared:

- The economic "benefit" of reducing or eliminating SEPTA, which would be the savings in public spending to rehabilitate SEPTA and continue services.
- The economic "cost" of reducing or eliminating SEPTA, which would be the loss of personal income due to contraction of the state economy as a result of the degraded transportation system.

The benefit-cost analysis showed that investment in SEPTA facilities and services at the levels of the proposed 10-year capital program would have substantial economic benefits that outweigh the public subsidy costs for residents of Pennsylvania. It specifically showed that rehabilitation and continued operation of SEPTA would return three dollars to the region and the state for every dollar spent on SEPTA, just in transportation benefits alone. In terms of total economic impact, the return to the region and the state would be over nine dollars for every dollar spent on SEPTA.

The analysis conclusively showed that the economic costs of shutting down or reducing SEPTA services would far outweigh the savings for residents of all areas of Pennsylvania. It showed that all three alternatives for reducing or eliminating services would have negative impacts on both the metropolitan area and the rest of the State of Pennsylvania:

- Considering only the transportation impacts themselves, the "benefits" of shutting down SEPTA would be only one-third of the detrimental transportation system costs that would be incurred.
- Considering all economic impacts, the "benefits" of not rehabilitating SEPTA are only one-ninth of the overall economic costs (income losses) which would be incurred.
- In terms of benefit-cost ratios, all the options of reducing or shutting down SEPTA are highly undesirable public policies.

Fully rehabilitating SEPTA, and continuing to operate SEPTA services, thus has a very high economic payoff for the region and for the State of Pennsylvania as a whole. Rehabilitating SEPTA is a desirable investment even if it costs several times what is now estimated. Investment levels currently available for SEPTA rehabilitation (about $100 million to $120 million annually) are inadequate. Investment levels of at least $450 million per year are strongly justified in terms of returns to the economy.

Complementary Methods

Forecasting and simulation models can be used in conjunction with benefit-cost analysis to identify how benefits and costs are reflected in the economy over time. Interviews, physical conditions analysis, case comparisons, and real estate market analysis all have been used with forecasting and simulation models to assess how the regional impacts might be reflected at the corridor level, or to augment the inputs to the forecasting and simulation models.

Method's Score Card

The following score card grades the performance of economic forecasting and simulation models according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity			✓
External Validity		✓	
Reliability			✓
Minimal Data and Resources	✓		
Transparency	✓		

Selected References

Cambridge Systematics, Inc., *Final Report: Investment in Public Transportation: The Economic Impacts of the RTA System on the Regional and State Economies* (Project A2077), prepared for the Chicago RTA, January 1995.

Cunningham, Steven R. and William F. Lott, *Griffin Line Corridor Study: Economic Impact Analysis, Connecticut Center for Economic Analysis,* Department of Economics, University of Connecticut, March 16, 1994.

The Urban Institute and Cambridge Systematics, Inc., *Final Report: Public Transportation Renewal as an Investment: The Economic Impacts of SEPTA on the Regional and State Economy,* prepared for the Delaware Valley Regional Planning Commission, June 1991.

Method: Multiple Regression and Econometric Models

Description

Multiple regression models are the most frequently used statistical tools in the social sciences to test a hypothesis. Multiple regression models infer causal relationships between a dependent variable, such as employment, land values, or building square footage, and various explanatory variables, including the existence of a transit investment, and transit service levels. Two of the most commonly used types of regression analysis in transit economic impact analyses are 1) hedonic price models; and 2) logistic regression.

<u>Hedonic Price Modeling</u>

The benefits of a transportation investment normally are capitalized into higher land values, reflecting the increased accessibility that affected properties enjoy. Measuring the value added by transit investments has become one of the most commonly used approaches to gauging the economic benefits of transit, in part because rich time series data on land values and property sales transactions are often available to support rigorous statistical analyses.

Regression analysis is the primary methodology used in such studies, because regression allows the effects of transit's presence to be separated out from the influences of other factors (e.g., regional location, topography, freeway proximity, neighborhood quality, available services) that bear on land values. When regression analysis is employed to attach a monetary value to different attributes of a property, the technique is often called "Hedonic Price Modeling." Dozens of studies have estimated the effects of U.S. rail investments on property values, fairly consistently showing that proximity to transit stations has a positive influence on single-family property values and commercial rents.

Logistic Regression

Multiple regression is most often used to model the relationships between "continuous" variables, that is, variables whose values range smoothly from minimum to maximum. There are instances, however, in which the economic impacts of interest (i.e., the dependent variable) are not continuous, but fall into discrete categories. A prevalent example is travel mode choice. Researchers frequently want to model a transit investment's impact on the modal choices of travelers. Travel mode is a multinomial variable: its values fall into several discrete categories (e.g., SOV, carpool, bus, rail). Researchers examining the effects of a transit investment on land use might also employ multinomial or binomial variables to represent different categories of land uses. In addition, models for alternative choice must often model non-linear relationships between the dependent and independent variables. For analyses such as these, researchers often use a variety of regression analyses known as logistic regression, or "Logit."

When to Use

In economic impact analysis, regression models are frequently used in evaluative studies where cross-sectional information is collected for the regression equation. The goal of the analysis is usually to isolate the effects of transit investments on mode choice or economic conditions, controlling for non-transit-related influences, such as exogenous economic trends and demographic changes. Regression models also serve as the basis for establishing causal relationships (e.g., measuring production functions) in many predictive techniques, including input-output (I-O) and forecasting and simulation models.[20]

Impacts Measured

Regression models by themselves are used most typically to measure generative impacts of transit investments. They have been used to measure a wide range of impacts, including changes in employment, sales, income, business starts, building square footage, and property values.

[20] There is an important distinction, however, between the initial estimation of a regression model, in which relationships between variables are discerned via the evaluation of empirical data, and the subsequent use of fully specified regression equations (as in I-O and forecasting and simulation models) to predict changes in dependent variables given changes in independent terms.

Advantages

Regression models allow researchers to distinguish, within a certain degree of probability, the amount of economic changes in a study area attributable to a transit investment, controlling for other possible explanatory factors (e.g., demographic characteristics). Although causality can never be proven in the strict scientific sense using regression (since all alternative explanations can never be ruled out), the outputs of well designed regression models are usually accepted as the next best thing to true causal explanations. Regression models are a widely recognized and accepted approach to isolating the impacts of transit investments. Regression software packages, such as SAS and SPSS, are readily available for use on personal computers.

Disadvantages

It is extremely difficult to fully specify a regression model wherein every relevant variable is included in the equation. If relevant variable are omitted, single-equation regressions will overstate the influence of transit on economic conditions. Furthermore, it is difficult to identify and collect data for all the independent variables that must be included in the regression equation. Without data on a given factor (e.g., population growth), a regression model cannot isolate that factor's impact on economic activity from the impact of the transit investment. Excluding a factor from a regression model can mean that impacts attributed to a transit investment were in fact caused by something else. Alternatively, an excluded factor may partially or totally obscure a transit investment's true impacts. Furthermore, because some of the independent variables likely will be correlated, an analyst must be vigilant to control for effects such as multicollinearity.[21] To be accurate, regression models often require extensive data collection, which can be time-consuming and expensive. Some expertise in statistical modeling and analysis is required to construct and interpret the results of a regression model.

Data Sources

Data that might find application in transit economic impact analyses are available from a variety of sources. Data on individual and household income, socioeconomic, and demographic characteristics for tracts are available for census sources such as summary tape file (STF) 3A and the Census Transportation Planning Package (CTPP) for metropolitan statistical areas. Readily available sources of data on real estate property transactions come from TRW-Redi (an on-line service of real estate property attributes across the United States) as well as regional proprietary sources (e.g., Black's Guide). Transit agencies also normally provide input data for transit economic analyses, such as ridership, average fares, and service levels (e.g., revenue vehicle-miles of service). Additionally, primary data sometimes needs to be compiled (e.g., through surveys, field inventories, etc.) to supplement these secondary sources. Among the standard personal computer statistical packages available for conducting multiple regression and Logit analysis are SPSS, SAS and E-Views.

[21] When independent variable are highly inter-related, the regression analysis becomes particularly sensitive to errors in sampling and measurement. This is referred to as multicollinearity.

Example **Regression Analysis – Hedonic Price Model:** A recent study examined the effects of rail transit proximity on single-family housing values in three California metropolitan areas: the San Francisco Bay Area, Sacramento, and San Diego. This was done through estimating a hedonic price regression model that associated single-family home sales prices with characteristics of the home, the neighborhood, and the location, including distance and adjacency to a rail station. The estimated regression model for Alameda County, in the Bay Area, is shown below.

The model, estimated using data from real-estate sales transactions, revealed that single-family home sales prices in 1990 went up with: house size (SQFT), lot size (LOTSIZE), number of bathrooms (BATHS), age of unit (AGE), number of bedrooms (BEDRMS), and median household income in the census tract where the unit is located (MEDINCOM). Based on the signs of the coefficients, the model also shows that higher shares of minority populations (PctBLACK) and PctHISPN) were associated with lower sales values.

In terms of proximity to transportation infrastructure, the model results show that distance from highways (HWYDIST) increases values and adjacency of a unit to a major highway lowers it slightly. On the other hand, for every meter an Alameda County home was closer to the nearest BART station, its sales price increased by $2.29, all else being equal. And being adjacent (within 300 meters) of a BART station (TRANADJ) increased sales values, on average, by $5,240, as shown in Table 4.5.

While regression results can be used to generate precise estimates, they are not easily interpretable or meaningful to those with little or no statistical training. To make the results more accessible and understandable, the values of all variables except those related to transit proximity can be set at their averages (means and medians); a range of transit proximity values can then be input into the model to produce a range of sales price estimates, and then plotted. This was done for both Alameda and Contra Costa Counties in the Bay Area, producing "land value gradients," as shown in Figure 4.3.

Simple plots of regression model outputs can produce results that are more revealing and insightful. As shown, the more urbanized Alameda County has a steeper gradient of sales price relative to distance than the more suburban Contra Costa County, and that on balance, the proximity advantages conferred by BART were greater in the Bay Area's suburbs.

Table 4.5 Coefficients for Alameda County Model

Dependent Variable: SALEPRICE(1990)	Alameda County Coefficient	Alameda County t-statistic
Home Characteristics		
SQFT[1]	110.62	27.48
LOTSIZE	1.81	5.79
BATHS	3,768.88	1.23
AGE	91.62	1.00
BEDRMS[2]	-5,523.37	-2.20
Neighborhood Characteristics[3]		
MEDINCOM	2.10	12.02
PctWHITE	-125,164.75	-1.62
PctASIAN	-175,514.43	-2.21
PctBLACK	-214,791.49	-2.66
PctHISPN	-225,039.93	-4.14
PctOWNER	-57,769.56	-4.92
Locational Characteristics		
HWYDIST	2.80	2.30
TRANDIST	-2.29	-10.50
HWYADJ	-108.43	-0.03
TRANADJ[4]	5,240.62	0.81
CONSTANT	182,376.87	2.23
R-squared		0.80
Observations		1,131

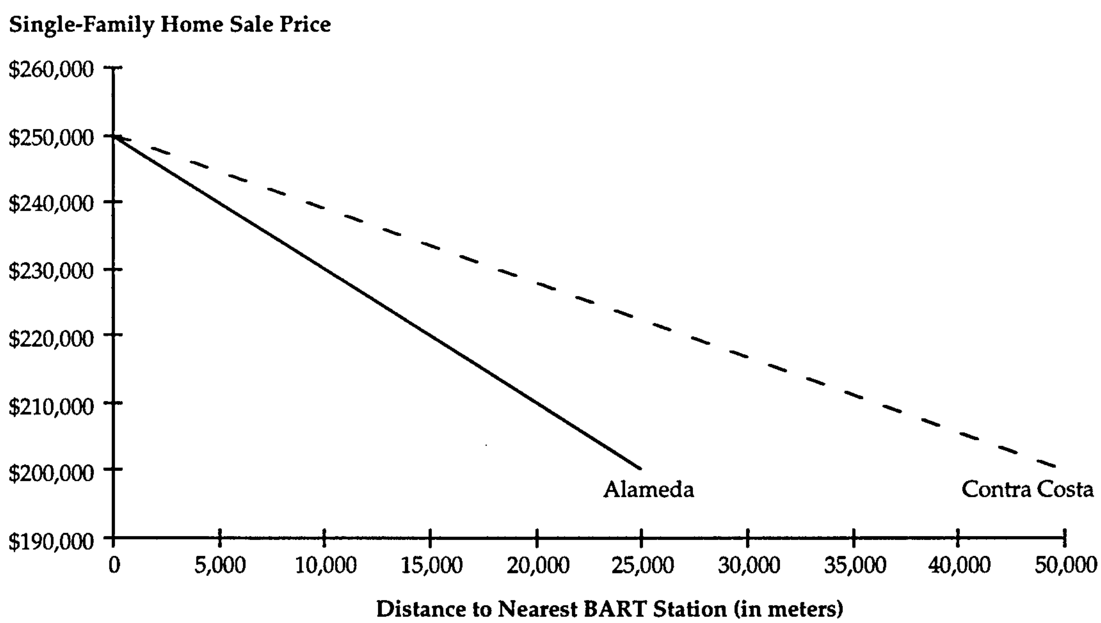
1 Note that this variable does not capture the same effects as BEDRMS (number of bedrooms). The size of a house and number of bedrooms are different attributes of the "bundle" of housing goods. Thus, hedonic price models contain both of these attribute variables and, as in the model presented, both normally perform quite significantly.

2 The negative coefficient applied to the number of bedrooms in the house is a standard finding of hedonic price models. Note that the model already controls for square footage of the house, which is the overall scale factor. Thus, for two houses of the same square footage, the one with fewer bedrooms will be more valuable than the one with more, because less area will be taken up for sleeping area and more for living area (e.g., dens, living rooms, etc.). In many markets, bigger homes with relatively fewer bedrooms are worth more than comparably sized ones with relatively large numbers of bedrooms (the 1960s vintage of home design). Factors such as number of baths add amenity value, but bedrooms – controlling for square footage – do not typically add value – rather, as shown in the model, they detract from value. In markets where home buyers place a premium on having more and larger bedrooms, then the variable bedroom should be positive, even when coupled with square footage. In the case of Alameda County, however, home buyers appear to prefer other types of space (e.g., kitchens, bathrooms).

[3] Under the neighborhood characteristics, house price declines significantly based on the presence of each race. The coefficients of the various race variables are all consistently negative, even for white-dominant census tracts. This appears to be a result of multicollinearity – in this case between racial make-up and income. In Alameda County, homes in Hispanic-dominant and African-American-dominant census tracts sell at a deep discount when compared with similar homes in white-dominant neighborhoods. Homes in Asian-dominant census tracts also sell at a discount compared to white-dominant neighborhoods. The multicollinearity distorts the coefficients; however there is a stronger decline in home values with reference to traditional minorities (blacks and Hispanics) than with whites and Asians. While one would also expect that the variable PctWHITE to be positive rather than negative, this aspect of the model is problematic. Nevertheless, strengths of the model in other areas generally overshadow these problems, particularly since the race variables are proxy controls for neighborhood characteristics.

[4] While the locational variable TRANADJ and other variables do not have significant t-statistics, it is standard practice to include insignificant variables in a hedonic price model as long as signs match a priori expectations and theory suggests they should be in the model. This study attempted to determine whether adjacency to a major transport node had a disamenity (or nuisance) effect on single-family home values, which theory would suggest it does. Thus, the model subjects the variables that theory suggests should be included to empirical scrutiny.

Figure 4.3 Single-family Home Sale Price



Source: J. Landis, S. Guhathakurta, W. Huang, and M. Zhang. *Rail Transit Investments, Real Estate Values, and Land Use Changes: A Comparative Analysis of Five California Rail Transit Systems.* Berkeley: University of California Transportation Center, Working Paper No. 285, 1995.

Complementary Methods

Regression equations form the foundation for I-O models and more sophisticated economic forecasting and simulation models. In addition, researchers frequently employ methods such as surveys, interviews, and physical conditions analysis both to build regression equations, and to support the findings of a regression model.

Method's Score Card

The following score card grades the performance of regression models according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity			✓
External Validity		✓	
Reliability		✓	
Minimal Data and Resources		✓	
Transparency		✓	

Selected References

Cervero, R., "Rail Transit and Joint Development," *Journal of the American Planning Association 60*, 1:83-94, 1994.

Cervero, R., *BART@20: Land Use and Development Impacts*, BART@20 Study, Monograph 49, Institute of Urban and Regional Development, University of California, Berkeley, 1995.

Cervero, R., P. Hall, and J. Landis, *Transit Joint Development in the United States, Monograph 42*, Institute of Urban and Regional Development, University of California, Berkeley, 1992.

Damm, D., S. Lerman, E. Lerner-Lam, and J. Young, "Response of Urban Real Estate Values in Anticipation of the Washington Metro," *Journal of Transport Economics and Policy 14*, 3:312-322, 1980.

Ferguson, B., M. Goldberg, and J. Mark, "The Pre-Service Impacts of the Vancouver Advanced Light Rail Transit System on Single-Family Property Values," *Real Estate Market Analysis: Methods and Applications*, J. Clapp and S. Messers., eds., Praeger, New York, 1988.

Landis, J., S. Guhathakurta, W. Huang, M. Zhang, B. Kukuji, and S. Sen, Rail Transit Investments, Real Estate Values, and Land Use Change: A Comparative Analysis of Five

California Rail Transit System, BART @ 20 Study, Monograph 48, Institute of Urban and Regional Development, University of California, Berkeley, 1995.

Method: Statistical and Non-Statistical Comparisons

Description

If the data needed to support regression analysis are not available, researchers may opt to make simpler statistical comparisons. Researchers can compare data on development, employment, wages, and other variables from both before and after data on a transit investment (i.e., longitudinal analysis) and similar data from another transit corridor as a control (i.e., a cross-sectional analysis). The method must be set up using the following variables:

$$\text{Effect of Transit} = \left(I_{TA} - I_{TB}\right) - \left(I_{CA} - I_{CB}\right)$$

where:

I = Economic impact of transit
T = Transit corridor being studied
C = Transit corridor used as a control
B = Before transit investment
A = After transit investment

Simple statistical comparisons can provide probabilities of obtaining sampled differences and indicate whether the observed changes or differences are significant. While the probabilities may lead researchers to claim that relationships exist between transit investments and economic activity, these tests never serve as proof.

Nevertheless, useful information also can be collected only through comparative analysis using matched pairs. Such studies compare the study area (containing the transit investment), with a similar (control) area that lacks transit service (cross-sectional comparison). Both control and study areas are then analyzed over time (longitudinal comparison), using data prior to and following the transit investment for the study area.

When to Use

This method is used primarily for evaluative studies when the study budget is small and/or good data are difficult to collect. It also may be employed when practitioners are not experienced in more quantitative techniques or results are needed quickly.

Impacts Measured

Statistical comparisons generally are used to measure redistributive impacts of transit investments. They have been used to measure a wide range of impacts, including changes in employment, sales, income, business starts, building square footage, and property values.

Advantages

This method is less data-intensive than regression modeling, and provides an intuitive sense of the impacts of transit investments on economic growth and development. Since it employs concrete cases, it tends to produce results that are more understandable to decision-makers (versus less transparent statistical methods like regression analysis).

Disadvantages

Comparable neighborhoods and subareas rarely can be found to control suitably for confounding influences. The closeness of a control to the study area is a subjective determination and is usually open to criticism. Furthermore, results may amount to a collection of anecdotal examples that policy makers may confuse with statistically valid results.

Even simple statistical tests require some minimum number of data points to be valid. In many cases, however, few data records are available. For example, while multiple data points are typically available for some variables, such as housing prices (with each house serving as an individual data point), other variables, such as square footage of commercial development, may have only a few aggregate data points for each time period or geographic area being studied. In these cases, statistical tests are impractical (i.e., they can be performed, but they will not provide meaningful results).

Data Sources

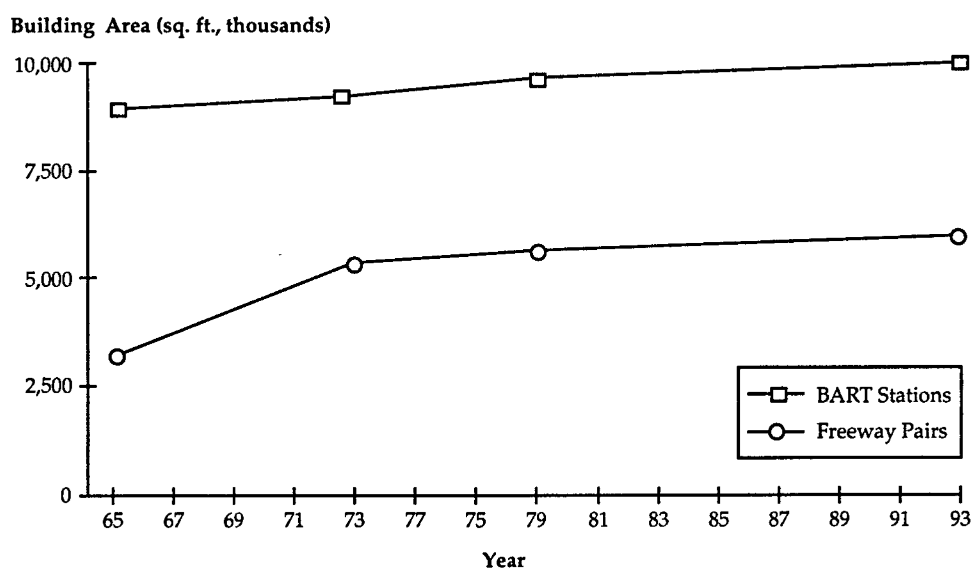
The data sources for use in statistical and non-statistical comparisons will be driven by the measure of interest to the analyst (e.g., employment, square feet of development, property values). Information on the number of square feet of development that has occurred in a transit corridor and comparison area can be obtained from a review of assessor's records or from local planning agencies. Data on property values can also be obtained from assessor's records, from the TRW-Redi on-line service (which provides property values from local assessors' records for many locations), and vendors such as County Home Data and the Multiple Listing Service (which sell information on real estate transactions, including sale prices).[22] Information on changes in employment are best obtained through surveys of businesses in the study area and the comparison area.

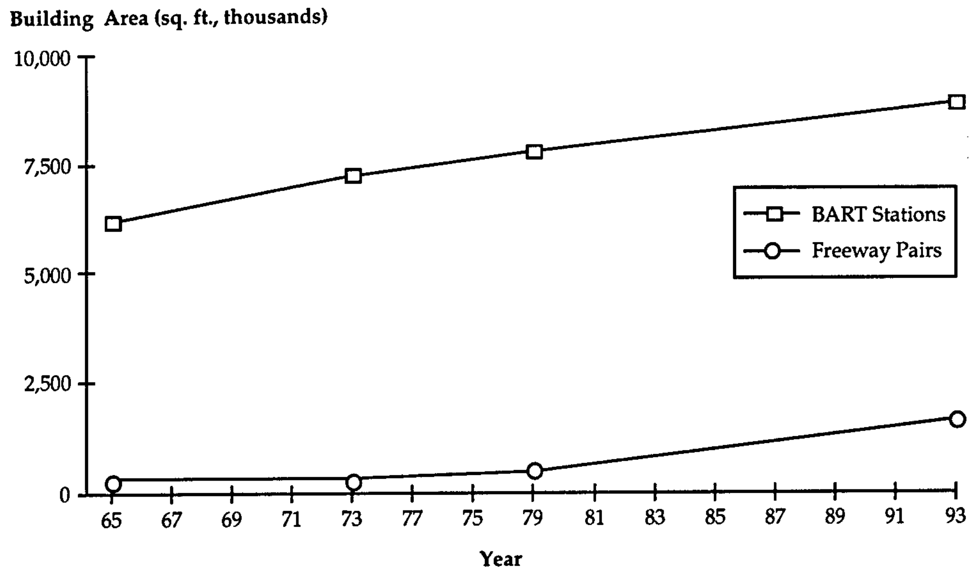
[22] Data on property values can also be obtained from assessor's records, from the TRW-Redi on-line service (which provides property values from local assessors' records for many locations), and vendors such as County Home Data and the Multiple Listing Service (which sell information on real estate transactions, including sale prices).

Example **Matched-Pair Comparison:** The recent *BART @ 20* study used matched pairs to compare differences in rates of housing development around BART stations versus nearby freeway interchanges along the Fremont and Richmond lines. Since both stations and interchanges are access points to regional networks, the analysis compared rates of housing development between these two competing settings. The chief matching criteria were that each paired station and freeway interchange be within two miles of each other, have similar surrounding land use compositions, and be connected by the same arterial roadway.

In all, nine suitable matched pairs were found. As shown in the graphs below, there was little difference in rates of single-family housing development among the paired stations and freeways during 1965-1973 (pre-BART service) and 1973-1993 (first 20 years of BART service). Within the same geographic areas, however, some 2,600 more multi-family units were built near BART stations from 1973 to 1993 than around nearby freeway interchanges.

The absence of sufficient numbers of matched pairs precluded the ability to attach probabilities, and thus statistical significance, to differences in rates of housing development across matched pairs. Still, the evidence strongly suggested that BART attracted significantly more multi-family housing near stations than interchanges, resulting in relatively high rates of transit commuting and walk access trips among station-area dwellers. This represented a positive and real redistributive impact.





Source: R. Cervero, *BART@20: Land Use and Development Impacts.* Berkeley: Institute of Urban and Regional Development, University of California, Monograph 49, 1995.

Complementary Methods

Focus groups, interviews, case comparisons, regression analysis, and stakeholder meetings can all be used to complement statistical comparisons.

Method's Score Card

The following score card grades the performance of matched-pair comparison according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity		✓	
External Validity	✓		
Reliability		✓	
Minimal Data and Resources		✓	
Transparency			✓

Selected References

Bernick, M., R. Cervero, and V. Menotti, *Comparison of Rents at Transit-Based Housing Projects in Northern California*, Working Paper 624, Institute of Urban and Regional Development, University of California, Berkeley, 1994.

Cervero, R. and J. Landis, "Assessing the Impacts of Urban Rail Transit on Local Real Estate Markets Using Quasi-Experimental Comparisons," *Transportation Research* 27A, 1:13-22, 1993.

■ 4.2 Methods for Measuring Redistributive and Financial Transfer Impacts

Method: Case Comparisons

Description

Most studies of transit's economic impact include a review of the experiences of other cities that have made similar transit investments. These case comparisons usually involve some combination of a literature review and interviews with or surveys of planners, business people, transit agency representatives, developers, brokers, and other informants who have knowledge about transit investments in other cities. Case comparisons allow researchers to gain insights into how a transit investment has affected economic growth and development in other communities, and can provide information that will help the researcher understand how a similar investment might affect his or her community.

When to Use

Case comparisons primarily are used for predictive studies. They can be used to support any goal if a case community with a similar goal can be identified. Case comparisons are often used for public relations campaigns to demonstrate the positive impacts that transit investments have had in other communities.

Impacts Measured

Case comparisons can be used to gain an understanding of any impact of interest that has been measured for a similar transit investment in another community. The case comparisons, however, cannot provide a definitive measure of any given impact since factors other than the transit investment unique to each case comparison can have a bearing on economic conditions. Typical measures of interest in case comparisons are actual changes in square feet of development within a corridor by land use, as well as changes in employment, property values, retail sales revenues, and personal income which can be directly linked to the transit investment.

Advantages

Case comparisons are relatively low-cost and easy to administer. A junior researcher can conduct the literature review, surveys, and interviews if provided with a well thought-out survey instrument or interview guide. In addition, decision-makers and a public unfamiliar with transit investments can gain a sense of comfort from reviewing real-world experiences. Because decision-makers and the public are comforted by real-world experience, case comparisons can be a powerful marketing tool for selling a transit investment to a wide range of audiences. Case comparisons also can help a community identify additional steps (such as modifications to zoning, changes to parking policies, and other supportive public policies) that can be implemented in conjunction with the transit investment to help realize economic development goals.

Disadvantages

While showing the advantages of transit investments, case comparisons also can mislead decision-makers and the public into thinking experiences elsewhere are easily replicable in their communities. Each community's experience with a transit investment is unique in terms of the physical, political, demographic, and economic characteristics of an area for which a transit investment is planned. In fact, even individual investments within a single community are unique and may not result in parallel economic impacts. Differences between communities and investments are not easily controlled for, and one cannot assume that the experiences of one community can or will be replicated elsewhere. The researcher must document these differences. Similarities and differences between the community where the investment is planned and the comparison communities should be documented in the presentation of case comparison results.

Data Sources

Information for case comparisons generally is obtained through a literature review, review of documents (e.g., EISs, planning documents, journal articles, TCRP reports, etc.) specific to the case comparison project, and interviews with planners, transit agency representatives, real estate professionals, and others who are familiar with the case comparison project.

Example **Economic and Social Impacts of Orange Line Replacement Transit Service:** The most significant characteristic of the study area is the diversity of the environment. Some parts of the area are densely developed, while others contain large amounts of vacant land. Housing varies from luxurious to abandoned, with much in between. Retail and business activity is scattered throughout the study area, with concentration of activity in a few areas.

Chinatown is densely populated with little vacant land. Residential uses compete with commercial, manufacturing, and institutional activity for remaining available land. Retail is an important component of the character of Chinatown, although the majority of the retail activity is outside of the study area boundaries. While housing is in increasing demand, housing prices are not overly high in the neighborhood compared to other areas of the city.

The South End has the highest average housing prices in the study area. The South End is characterized by varied land use patterns, including residential, retail, and some manufacturing. Part of the South End, north of W. Canton Street, is largely a middle to upper middle income area, which has seen an enormous housing boom in recent years. Upscale retailing accompanies the renovated and refurbished housing. The lower portion of the South End has not experienced such rapid residential growth, although housing prices are rising. Many younger, affluent professionals live in the South End, and the population is racially mixed.

Roxbury has the most vacant land of the neighborhoods in the study area. Housing prices are lower than the other two neighborhoods, and speculation has not occurred to any great extent. The population is predominantly black with a median income below the city-wide average. Land use is dominated by housing, although some significant retail activity also takes place in Roxbury.

The analysis indicates that there will be economic benefits experienced by communities in the study area, particularly the lower portion of the South End and Roxbury, as a result of replacement service. In the short run, the lower part of the South End (south of W. Canton Street) will likely experience increases in property values and housing prices as already seen in other parts of the South End. Light rail transit is likely to contribute to accelerating this trend in the lower part of the neighborhood which is already showing a tendency to experience economic growth.

Roxbury will experience growth as well, although major benefits are not expected within the next 10 years. Other factors are necessary to bring about a strengthening of the economy, including addressing the problems of blight, vacant land, construction of affordable and market rate housing, and the increase in retailing activity. These are not changes which will take place immediately. Rather, Roxbury is expected to experience economic growth in the long term (10-20 years), after government and community development efforts, along with market forces, have created the development opportunities to address the various factors. The permanence of light rail transit can contribute to strengthening Roxbury's long-term economic growth by making the area more attractive for development.

Chinatown and the upper portion of the South End are expected to continue their current patterns of high growth, independent of Orange Line replacement service. Institutional development in Chinatown and well-established patterns of middle to upper income housing in the upper South End will likely dictate development activity in those areas.

Complementary Methods

Because case comparisons do not measure impacts particular to the investment under consideration, they almost always are conducted in conjunction with other economic impact methods. In fact, they are a good accompaniment to any of the other economic impact analysis methods discussed in this document. They often embellish the findings and help to illuminate insights gained from more rigorous statistical analyses focused on variation across variables, such as regression analyses.

Method's Score Card

The following score card grades the performance of case comparisons according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity		✓	
External Validity	✓		
Reliability		✓	
Minimal Data and Resources		✓	
Transparency			✓

Selected References

Cambridge Systematics, Inc., under contract to Tippetts, Abbett, McCarthy, Stratton, *Economic and Social Impacts of Orange Line Replacement Transit Service*, prepared for the Massachusetts Bay Transportation Authority, May 1988.

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Team Four Research, et al., *Preliminary Engineering for Major Transit Investments – St. Louis (Missouri-Illinois) Metropolitan Area: Technical Reports 19-23*, June 30, 1986.

Method: Interviews/Focus Groups/Surveys

Description

The nature and magnitude of a transit investment's economic impacts are influenced by local factors that vary from city to city. The opinions and experiences of local experts, corporate leaders, business owners, developers, community members, and other parties often are used to gain an understanding of the unique local environment, and to help estimate the economic impact of a transit investment. Typically, personal or telephone interviews are conducted with a number of local experts to explain the transit project and elicit opinions regarding what its impact was, or likely will be.

Alternatively, focus group discussions sometimes are conducted that bring a range of participants together to exchange ideas about the likely impacts of an investment. The underlying goal of interviews and focus groups is to gather information from the participants, rather than to reach a consensus. It is left to the researcher to synthesize the information collected. The interviewer or facilitator of the focus group needs to be skillful in drawing out responses from participants, without influencing answers. Surveys and the Delphi Method provide additional methods for collecting this type of information. If a survey is conducted properly and contains enough respondents, statistical methods can be used to analyze the results.

The aim of each of these techniques is to elicit enough insights based on personal experiences and lessons across a representative sample of informants to draw reasonably reliable inferences on transit's impacts on land use patterns, business locations, and other economic outcomes.

When to Use

Interviews, focus groups, and surveys can be used for both predictive and evaluative studies. These methods have been widely used to measure a wide range of impacts associated with transit investments.

Impacts Measured

These techniques typically are used to gain an understanding of potential redistributive and (some) transfer impacts (e.g., impacts on property values). The techniques cannot be used to provide exact estimates of impacts, but rather are best suited for predicting the direction (i.e., positive or negative) and order of magnitude of economic impacts.

Advantages

Local experts frequently have knowledge about the development climate in a particular corridor or community that might not be apparent to a researcher. For example, brokers can provide information about the overall real estate development climate of a region, and may understand the competitive position of a corridor within a regional context. Planners can provide information regarding the planning tools available for supporting development in a transit corridor.

Focus groups are useful because they bring together parties who might not otherwise interact. As a result, new perspectives about a transit investment's likely impacts may emerge. This "insider information" is critical for predicting how a transit investment might influence economic growth and development in a transit corridor.

These methods are relatively easy and inexpensive to use[23], and can serve as both a tool for collecting information, as well as a tool for providing information to the public about the proposed investment. Analysts can provide participants with information about a specific project or the experiences of other communities that will help participants better understand and relate to a proposed transit investment. These methods also are good tools for trying to understand where within a corridor development might occur.

Disadvantages

Interviews and focus groups are based on opinions and perceptions. Participants may not be familiar with a particular type of transit investment, and therefore may not be able to provide informed input about the investment's likely economic impact. Furthermore, participants may bias their responses based on their own opinions, perceptions, and stakes in the project. For example, a developer who believes the project might improve the marketability of a piece of land he or she owns might be inclined to oversell future benefits, while a business owner who believes his or her property might be negatively impacted by station area traffic might overstate potential negative impacts corridor-wide. These techniques can be compromised by personality conflicts, dominance by individuals, misinterpretations by researchers, and participant disinterest. Focus group facilitators and interviewers must be trained to elicit information so as to avoid such biases. Surveys and interview guides must be developed so as not to lead the respondent. These tools should all be pretested prior to full-scale implementation.

Data Sources

These methods do not rely on the collection of data from secondary sources. Instead, they depend on primary data collection. The analyst may require assistance in identifying appropriate participants for focus groups, interviews and/or surveys. Transit agency officials, economic development agencies, business groups (e.g., chambers of commerce), elected officials, and developers can often suggest appropriate participants.

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[23] Any market research firm can provide a unit estimate of the cost of conducting surveys, interviews, and focus groups.

Example **Interviews with Local Experts:** In 1993, the Chicago Regional Transportation Authority (RTA) undertook a study to analyze the economic impacts of the RTA on the Chicago Metropolitan region and state economies. The study provided a quantitative analysis of the impacts of the RTA system's current services and proposed capital improvements on the overall economy of the Chicago Metropolitan area, and the State of Illinois. The project analyzed the impacts of the RTA system in terms of transportation benefits, economic benefits, air quality benefits, and other specialized impacts. To help provide a qualitative understanding of these impacts, a series of interviews with three groups: planning and economic development officials, businesses in the metropolitan area, and transit-dependent population were conducted.

The purpose of the interviews was to identify local and regional concerns and expectations regarding relationships between RTA services and economic activity in the area. The interview process was designed to gather information, and not as an in-depth survey. Candidates for interviews were selected by the consultant team and RTA from three groups:

- Economic development and planning agencies (at the regional and local levels);
- Businesses (representing a cross-section of industry sectors and geographic locations throughout the metropolitan area); and
- Transit-dependent populations (agencies and advocacy groups).

A total of 41 interviews were conducted.[24] While the interview process was not designed as a formal survey, interview guides were developed to achieve consistency in the questions asked during the interviews. Overall, the purpose of the interviews was to gather information on two key areas:

- What role does RTA currently play in the economy of the area? This includes how workers and customers use the system, and how the system has affected business location and business attraction efforts.

[24] A selected list of organizations interviewed includes: Illinois State Chamber of Commerce; Northeastern Illinois Planning Commission; Metropolitan Planning Council; McCormick Place Convention Center; Joliet-Will County Center for Economic Development; City of Chicago Department of Planning and Economic Development; Chicago Convention and Tourism Bureau; O'Hare – Ground Transportation Office; CTA – Public Relations; Chicago Board of Trade; Federal Reserve Bank of Chicago; McDonough and Associates Engineering; Marshall Fields; Sears; Sara Lee Corporation; Stein & Company; MCL; Prudential Realty Group; AFL-CIO Chicago Federation of Labor; Washington National Insurance Company; Allstate Insurance; Dean Whittier Discover Card; Art Institute of Chicago; Lincoln Park Zoo; McCormick Place Convention Center; Field Museum of National History; and Chicago Botanical Garden.

- What would happen to economic activity in the region under various scenarios for the future investment in RTA services? These scenarios were defined as:
  - Continued funding of RTA services at current levels;
  - Funding at a level to bring the RTA system to a state of "good repair";
  - Funding at a level to bring about expansion of the system, beyond "good repair"; and
  - Total shutdown of the system.[25]

In addition to these key questions, the organizations were asked about other transit or transportation improvements they would like to see, to further the purposes of economic growth and development in the region.

The interview guides used for the interviews with economic development and planning agencies follow.

[25] Since the interviews were conducted, the scenarios being used for analysis for this study have been slightly reconfigured to replace the total shutdown alternative with a more realistic deterioration alternative. As the findings from these interviews are qualitative, and serve to support and augment the quantitative analysis, the findings regarding agency and business views of the last scenario are still useful.

Economic Development Interviews – Questions

Agency Name: ______________________
Address: ______________________
Contact Person: ______________________
Phone: ______________________
Date: ______________________

We are evaluating the impacts of RTA in the Chicago regional economy. We are conducting interviews in order to better understand the role of RTA in supporting existing business activity, as well as economic development officials to learn about your views on the role of RTA in economic development in the region.

1. Please describe your organization and its role and activities in economic development. To what extent has your organization been involved in specific outreach and contacts to attract specific businesses/industries to the region?
   a. Target industries?
   b. Target outside areas?
   c. Target locations in the region?
2. Have particular businesses specifically mentioned transit access as a contributing factor in their decision to locate (or not locate) in the region?
   a. If so, what types of businesses? Why?
3. Have particular businesses specifically mentioned road congestion or parking cost as a contributing factor in their decision to locate (or not locate) into or within the region?
   a. If so, what types of businesses? Why?
4. What factors have contributed to or inhibited attraction and economic growth potential of the region?
   a. Where does public transportation fit in this list of factors?
   b. Where does road traffic congestion or parking cost and availability fit in this list of factors?
5. Is current public transportation access a supporting factor in economic development/business attraction?
   a. For what types of businesses?
   b. For what location areas in the region?

6. Now let's consider four scenarios for the system. The analysis will be at the systemwide level, so the scenarios refer only to the overall system, and not any specific service or element within the system:

   - The RTA system will be funded and supported at the current level of investment. No additional levels of funding or upgrading or improving services or stock will be assumed beyond the level of current plans.

   - The RTA system will be funded and supported to bring the system to a state of "good repair," with sufficient investment to bring the current system to a point where it is operating well. This would result in a system which operates better than it does today, but does not involve expansion of the system into new markets or improve the system beyond what has already been programmed.

   - The RTA system will be funded and supported to bring the system beyond a state of "good repair," to include some additional services or stock. This would result in a system which operates better than it does today, and includes expansion of the system into new markets and increased services in strategic existing markets.

   - All investment in the RTA will cease, and all RTA services will be immediately and permanently shut down.

   For each scenario, how would the change affect business attraction, retention, and expansion? What types of business? How affected? Why?

   - Services in good repair
   - Continuation of existing services
   - Expansion of services
   - No services

7. How would each scenario affect the type and amount of tourism that can be attracted to the region?

   - Services in good repair
   - Continuation of existing services
   - Expansion of services
   - No services

8. What new programs and changes in economic development programs can be developed to help mitigate the negative impacts of the loss of transit service on business attraction?

9. What improvements in transit service would most benefit economic growth and business attraction?

   a. Types of improvements?
   b. What businesses would benefit?
   c. Why businesses would benefit?

A summary of major findings from the economic development and planning interviews includes:

- Economic development professionals identified that overall, access to labor is a critical issue for businesses. To the extent that transit services provide that access, it is very important. City center business locations depend much more heavily on transit than suburban locations for moving their labor force.

- Several agencies interviewed stated that transit access is a contributing factor in decision-making for business location.

- Several planners interviewed felt that the key factors which have contributed to or inhibited business attraction and economic growth potential in the region are congestion and lack of transit options.

- A number of agencies felt that public transportation is a supporting factor in economic development and business attraction. It alone does not control business location decisions.

- One tourism agency interviewed noted that the direct access available by transit to the airports is beneficial to tourism.

The economic development and planning officials were asked to consider the potential impacts of various levels of future investment in the RTA system on their efforts to attract business and support existing business growth. The following summarizes their responses:

Scenario 1 – Supporting the RTA System at the Current Level of Investment. Six of the organizations interviewed were strongly opposed to this scenario as inadequate to support long-term economic growth. They feared that this scenario would ultimately cause the deterioration of the system and declining ridership. Three organizations indicated that this scenario would represent a basic minimum commitment in order to support long-term economic growth in the region. One organization felt that neither this scenario nor the "good repair" scenario would provide as much impact on economic activity as the expansion scenario, as current service does not adequately support economic activity.

Scenario 2 – Bringing the RTA System to a State of "Good Repair." One city agency felt that this scenario would be the most advantageous to the city. It preferred support of the existing RTA system, rather than the expansion because it felt that RTA expansion may benefit the suburbs to the detriment of the city. Six of the organizations indicated that this scenario would be the minimum, but not optimum, sufficient response necessary to ensure long-term economic growth. Two organizations, both representing suburban areas that are growing aggressively, opposed this as an inadequate response to serve the needs of growth and development in the suburbs. Convention planners mentioned the need for public transit for competitiveness.

Scenario 3 – Investment in Expansion of RTA Beyond "Good Repair." One agency expressed concern about the benefits of this scenario, indicating that expansion without control would likely occur at the expense of the city. One suburban organization was quite indifferent to the impact of all transit investment scenarios. The other eight economic development and planning organizations felt that this scenario would support their areas of interest, and would be good for business growth and expansion in the region overall.

Scenario 4 – Shut Down of RTA Services. The organizations interviewed overwhelmingly rejected this scenario as "ridiculous," "devastating," "crippling."

Economic development and planning officials were also interviewed about what other transit or transportation improvements would assist in their efforts in business growth and attraction. Comments from the various agencies include:

- Transit should expand to new markets – many of the agencies interviewed stressed the importance of getting transit access to the fringes of the city and the suburban areas to allow for access to labor.
- Transit expansion to fringe areas and other transportation policies need to be connected with strong land-use policies to prevent further sprawl.
- Several agencies felt that the transit system needs to be more "user friendly." This includes signage, cleanliness, security, and quality of custom-designed services. This would also benefit tourism.
- Two agencies mentioned the importance of improvements in airport service including transit baggage cars, or racks for luggage.

Complementary Methods

Interviews, focus groups, and surveys are good complements to the full range of economic impact methods. Because they are not good tools for measuring generative impacts and are vulnerable to potential interpretive biases, however, they should be coupled with tools such as forecasting and simulation methods, benefit-cost analysis, or I-O models.

Selected References

ECO Northwest, *Land Use and Economic Impacts Results Report, Hillsboro Corridor, Alternatives Analysis*, September 1992.

Federal Transit Administration and Massachusetts Bay Transportation Authority, *South Boston Piers/Fort Point Channel Transit Project, Final Environmental Impact Statement/Final Environmental Impact Report*, prepared by URS Consultants, Inc., December 1993.

Grefe, R. and A. McDonald, *The Economic and Financial Impacts of BART: Final Report*, Urban Mass Transportation Administration, U.S. Department of Transportation, Washington, D.C., 1977.

The Urban Institute and Cambridge Systematics, Inc., *Final Report: Public Transportation Renewal as an Investment: The Economic Impacts of SEPTA on the Regional and State Economy*, prepared for the Delaware Valley Regional Planning Commission, June 1991.

KPMG, *Fiscal Impact of Metrorail on the Commonwealth of Virginia*, 1994.

San Diego Association of Governments, *San Diego Trolley: The First Three Years – Summary Report*, Urban Mass Transportation Administration, U.S. Department of Transportation, Washington, D.C., 1984.

Method: Physical Conditions Analysis

Description

Physical conditions analysis focuses on identifying opportunities for development within a proposed transit corridor. This method is based on the well documented premise that a transit investment will influence development in a corridor only if land is available and the market conditions within the corridor are competitive with other areas of a region.

A field survey is a straightforward method of assessing the development conditions within a proposed transit corridor. Direct observation allows the researcher to check land use and property maps, and verify aerial photographs. Parcel maps and associated documents are also useful because they indicate land ownership. Because parcel-level inventories of built environments are not readily available from secondary sources, field surveys and observations may be the only ways to assess development opportunities and constraints effectively. Often, physical conditions analyses are summarized in a matrix checklist form, with columns used for enumerating both assets and constraints to development.

When to Use

Physical conditions analysis can be used for both predictive and evaluative studies. It is a particularly useful tool for assessing a corridor's potential for economic development, to pinpoint sights for private sector participation, or to identify constraints to development. Among the constraints to land use economic change that might be identified are: physical barriers, lack of vacant or buildable land, urban blight, poor neighborhood services, traffic congestion, inadequate access to planned stations, and patterns of land parcelization. Physical conditions analysis is frequently used for alternatives analysis.

Impacts Measured

Physical conditions analysis generally is used to predict redistributive impacts, usually in terms of potential square feet of development by land use type, potential property tax revenues, or potential employment gains.

Advantages

Physical conditions analysis is relatively low-cost and does not require substantial data. It allows the researcher to determine actual land use and economic conditions within a corridor, and to identify obstacles to development or features that will support development. In other instances, researchers may want to verify secondary data with first-hand examination. There may be certain aspects of economic activity that only direct observation can detect, such as the block-by-block composition of existing development, the location, shape and orientation of available parcels, whether potential station areas already support active retail and commercial activity, and existing traffic patterns in the proposed corridor.

Disadvantages

Physical conditions analysis is not practical on a regionwide scale, and so is limited to predicting redistributive and transfer impacts. The potential land development impacts identified through physical conditions analysis should be considered speculative, since factors such as a land owner's willingness to develop a parcel or the environmental conditions of a parcel will influence the degree to which the development potential is realized. Analysts frequently ignore constraints to potential development (e.g., minimum possible roadway level of service), and often assume neighborhoods surrounding transit nodes will be fully built out.

Data Sources

Physical conditions analysis does not utilize secondary data sources. Instead, it is used to collect primary data through observation. Some tools that can assist with physical conditions analysis include assessors' or other parcel maps, USGS maps, and aerial photographs.

Example **Economic Development and Land Use Plan – Dallas Area Rapid Transit Starter System:** In 1989, Dallas Area Rapid Transit (DART) approved a system plan that included a new 66-mile light rail system. Twenty miles of this light rail system was designated as the Starter System. Land use patterns and future real estate development in the corridors would be influenced by construction of the light rail system, and DART and the City of Dallas worked together to ensure that future development, land use, and the light rail system would be mutually supportive. In addition, the capital investment in the corridors would help to support development in areas that had experienced little investment in the built environment in recent years. In order to capitalize on the economic development and job creation opportunities created by the light rail investment, DART and the City of Dallas jointly funded an economic development and land use study.

The study provided a set of tools to guide and assist the development process so that the affected neighborhoods, DART, and the city could reap the greatest benefit from the investment in the light rail system. The study work plan was organized around the following five separate tasks:

1. Study Initiation: Established the framework for the study and for the extensive Citizens Participation process and included data collection, field work, identification of goals and objectives for each of the corridors, and a review of the experience of other cities with land use and development in the vicinity of light rail stations.

2. Recommended changes to the city's Growth Policy Plan were discussed through focus groups with the public. Interviews were held with numerous individuals throughout the corridors, including businesspersons, representatives of chambers of commerce and economic development organizations, and concerned citizens.

3. Corridor Analysis: This work included field work and meetings with local community leaders. A thorough market analysis for each corridor was used to identify development opportunities in each corridor and to shape the alternative Development Concept Plans.

4. Station Area Planning Support: Specific market analysis for each of eight station areas (10 stations) within two key corridors identified the type and quantity of development anticipated for each station area. Implementation strategies were used to stimulate public, private and joint development.

5. Project Development Opportunities: Three specific "early action" projects were identified that could be undertaken immediately,

including identification of the key players, timing issues, and potential funding sources.

The study also described the general impacts of transit systems on land use and economic development in selected cities, including the experience of other communities with urban revitalization projects which were comparable to the three Development Opportunity Sites. The impact of transit on land use and economic development varies widely among North American cities. Systems that have been built within the past 25 years provide the best examples of what might happen in Dallas. This is because the impacts of transit in cities that grew up around transit systems are different from the impacts of transit in cities in which development patterns were established prior to construction of a transit system.

The experiences with development associated with transit systems has been mixed. Clearly, a strong economy is needed to stimulate development in the corridors, with or without additional public incentives. In rapidly growing cities such as Vancouver and San Diego, the transit agencies have been able to profit from development agreements with developers eager to connect with the transit system. Cities such as Portland and Atlanta have implemented aggressive, comprehensive programs to lure developers to the corridors with mixed results. Sacramento and San Jose, two auto-dependent cities that have made little effort to stimulate development around stations, have seen minimal development activity directly related to transit systems.

In economically distressed areas, development is unlikely without substantial public assistance. Economic development programs of a broader nature than programs solely related to transit-oriented development are necessary for areas similar to the corridors in the Southern Sector of Dallas.

Complementary Methods

The purpose of physical conditions analysis in the context of economic impact analysis is to identify sites with development potential or to identify barriers to development. It usually is used in conjunction with case comparisons, interviews/focus groups/surveys, and real estate market analysis to determine how transit might impact development trends and densities.

Method's Score Card

The following score card grades the performance of physical conditions analysis and other methods according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity	✓		
External Validity	✓		
Reliability		✓	
Minimal Data and Resources			✓
Transparency			✓

Selected References

Cambridge Systematics, Inc., *Final Report: Economic Development and Land Use Plan – Dallas Area Rapid Transit Starter System*, prepared for Dallas Area Rapid Transit and City of Dallas, October 1993.

Korve Engineering, Inc., *Stockton Multimodal Transportation Facility: Site Feasibility and Needs Assessment: Working Paper 5*, prepared for the San Joaquin County Department of Public Works, September 9, 1991.

U.S. Department of Transportation, Federal Transit Administration and the Government of Puerto Rico, Department of Transportation and Public Works, Highway and Transportation Authority, *Final Environmental Impact Statement: Tren Urbano*, San Juan Metropolitan Area, Puerto Rico, November 1995.

Method: Real Estate Market Analysis

Description

Transit economic impact studies frequently incorporate traditional market analysis to identify the competitive position of the corridor, or specific sites within the corridor, relative to other areas within the region. The market analysis helps to determine whether existing conditions in the corridor will support new development, and the degree to which the location of transit stations might increase the corridor's development potential. Indicators of a healthy real estate market and positive land use impacts of transit include rent and land value premiums, low vacancy rates, rapid net absorption, high market share capture rates, and rapid land assembly.

When to Use

Real estate market analysis techniques are widely used for predictive studies, and can also be used for evaluative studies. This technique typically is used for alternatives analysis, or when the goal of the investment is corridor economic development, or to encourage private sector participation in the project.

Impacts Measured

Real estate market analysis is used to measure redistributive and transfer impacts. Impacts generally are reported in terms of square feet of development, which then can be converted into employment and sales using standard conversion factors.[26]

Advantages

Market analysis can be relatively low-cost, although data from private vendors can be expensive and may require substantial "number crunching" to use effectively. Market analysis based on comparisons ("comps") is also an accepted real estate industry practice, and the results are easily understood. Market analysis can be completed in a relatively short timeframe.

Disadvantages

Market analysis must be conducted by a researcher experienced with real estate analysis. It can be particularly data demanding when comparisons ("comps") are necessary (i.e., information on real estate markets that are similar except in terms of transit provision). Proprietary data can be incomplete, with lots of missing values. There may be inconsistencies in how variables are measured, such as where office rents are based on asking prices, negotiated amounts, full service provisions, and effective rents (accounting for vacancy rates). As with many predictive methods, an assessment of how much transit might stimulate development requires some speculation and reliance on expert opinion. Accordingly, market analyses easily can be biased by the researcher.

Data Sources

Market analysis usually relies on data from government sources, such as building permits and tax assessment records, and data from private data vendors such as:

- Dun's Market Identifiers: can be used to track business activity over time by zip code.
- TRW-Redi: an on-line data service that provides complete property records from local tax assessors.
- Urban Decisions Systems and National Planning Data Services: use Census data to develop market profiles at the zip code or census track levels.

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[26] See the Highway Capacity Manual for standard conversion factors for number of employees per thousand square feet of space by land use type. The Institute of Transportation Engineers *Trip Generators* (5th Edition) and the trade censuses prepared by the U.S. Department of Commerce are additional sources for conversion factors.

- County Home Data and the Multiple Listing Service: compile data on real estate transactions and sales prices over time.
- Realtors and real estate brokers: provide information on absorption rates by type of activity (retail, office, industrial), vacancy rates over time, and lease rates.

These data can be used to estimate how much building space, by type of activity, will be in demand in the corridor in the future without the transit investment. Using information gathered from methods, such as interviews, physical conditions analyses, and case comparisons, researchers can predict how much additional development might be supported if the transit project is built.

Example See the example described in the Physical Condition Analysis: *Economic Development and Land Use Plan – Dallas Area Rapid Transit Starter System.*

Complementary Methods

Real estate market analysis is most effective when combined with interviews/focus groups/surveys, physical conditions analysis, and case comparisons.

Method's Score Card

The following score card grades the performance of real estate market analysis according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity		✓	
External Validity	✓		
Reliability		✓	
Minimal Data and Resources			✓
Transparency			✓

Selected References

Cambridge Systematics, Inc., under contract to Tippetts, Abbett, McCarthy, Stratton, *Economic and Social Impacts of Orange Line Replacement Transit Service*, prepared for the Massachusetts Bay Transportation Authority, May 1988.

Cambridge Systematics, Inc., *A Review of Methodologies for Assessing the Land Use and Economic Impacts of Transit on Urban Areas,* prepared for the U.S. Federal Transit Administration, June 1995.

Cambridge Systematics, Inc., *Final Report: Economic Development and Land Use Plan – Dallas Area Rapid Transit Starter System,* prepared for Dallas Area Rapid Transit and City of Dallas, October 1993.

Method: Fiscal Impact Analysis

Description

Because transit operations usually require ongoing public funding, their likely impacts on government revenues and expenditures, including tax revenues, can be of interest in the investment decision process. A fiscal impact analysis model can be used for this purpose.

Fiscal analysis involves the use of projections of future development, employment, income, sales, and other factors derived via any of the methods discussed above, to compute estimates of tax revenues. Spreadsheet models typically are used to make these calculations. For example, gains in employment and income will translate into increased income tax revenues. Similarly, increases in retail sales and real estate sales will yield sales tax revenue. The final result of most fiscal impact studies is a cash flow pro forma of the proposed investment, comparing the stream of revenues the investment is likely to produce with ongoing public outlays for construction, operation, and maintenance.

When to Use

Fiscal impact analyses measure transfer impacts. They frequently are used when projects are expected to require operating and capital subsidies from local governments.

Impacts Measured

Fiscal impact analyses can be structured to measure any number of tax impacts, including changes in revenue intake from property taxes, sales taxes, corporate income taxes, and personal income taxes. The models can be structured to measure tax impacts for any variety of jurisdictions, ranging from municipalities to special assessment districts. On the cost side, fiscal impact analyses identify the size and duration of capital and operating shortfalls and should include alternative farebox recovery ratios. As a bottom line, the pro forma cash flows should estimate the net operating cost borne by local governments through general taxes.

Advantages

Fiscal impact analyses determine overall the financial commitments that local jurisdictions must make to see public transit projects through to completion, both in terms of size and duration. Local governments may use these results for financial planning purposes. They also can be used to help assign proportional costs to the beneficiaries of the transit investment, including private property owners and jurisdictions located along the alignment. Fiscal analyses can also highlight possible inequities in how projects are financed (e.g., who pays versus who benefits), and can identify how financial programs fare in terms of tax equity and regressivity, buoyancy, efficiency, resistance, transaction costs, and other evaluative criteria.

Disadvantages

Fiscal impact analysis may reveal the need for significant taxpayer subsidy contributions to maintain reasonably low fares. An analysis may become complex when transit systems cross through multiple jurisdictions, where each jurisdiction has its own budget. Even when a fiscal analysis covers a single jurisdiction, it requires careful and methodical examination of all possible public expenditures and potential revenue sources. The results are difficult to compare to the project's forecasted economic impacts such as job growth or increased gross regional product. Finally, there is danger that public resource allocation will be based primarily on fiscal impact analyses, even though economic appraisals based on benefit-cost analysis best express the effects of a transit investment on the public welfare.

Data Sources

Depending on the scope of the investment, an analyst should collect the most recent budget for all impacted public agencies and local jurisdictions as well as the operating budgets or annual reports of all transit agencies and highway/public works departments.

Example To estimate the impacts of economic changes on local and state levels of government, the Pennsylvania Economy League (PEL) applied its Fiscal Impact Models. These models were developed by, and are maintained by PEL. The models are described in more detail in the report: <u>Local Fiscal Issues in the Philadelphia Metropolitan Area</u> by Thomas Luce and Anita Summers; University of Pennsylvania Press, 1987.

The model of local government impact represents the overall impact on all municipal governments within the metropolitan area. It was constructed based on detailed analysis of revenues and expenditures of the City of Philadelphia and typical communities in each county of the metropolitan area.

The analysis of local government revenues takes into account the fact that there is great variation in taxes among municipalities in the metropolitan area. In Philadelphia, the wage tax accounts for 69 percent of local revenue, while real estate taxes account for 30 percent of local revenues. Outside of Philadelphia, the real estate tax, applied to resident and business property, is the principal tax. It is the only local tax on the New Jersey side. On the Pennsylvania side, non-property taxes collected by municipalities also include wage and occupation taxes, per capita taxes, mercantile or business privilege taxes, and real estate transfer taxes. Future collections of these local revenues from all sources will reflect changes in regional employment, income, and population.

The model assumes that revenue from residential real estate taxes would decline with reduced demand for housing or shifts to lower housing prices, both of which would occur as regional income drops. It further assumes that income from commercial and industrial real estate taxes, as well as other business taxes, and occupation taxes, would fall with declining employment. Revenue from per capita taxes and local non-tax revenues would be proportional to changes in population.

The analysis of local government expenditures incorporates support to a variety of other activities, including, education (public schools), safety services (police, fire, and jail), public works (roads, sewer system, etc.), public housing development, parks and recreation, public welfare, health and hospitals, and administration and finance.

The model takes into account the fact that reductions in population and employment would cause some savings in local government spending, but that there are significant fixed costs for infrastructure, administration, and maintenance that do not decline with population change.

The model of state government impact indicates how state government revenues and expenditures would be affected by reduction or elimination of SEPTA services. State government revenue sources include the personal income taxes, corporate profit taxes, the sales tax, motor fuel tax, lottery, and various fees. Revenue from these sources would change proportionally to changes in population, employment, and personal income. State government expenditures support a wide variety of programs, ranging from highways to health care to public welfare. For purposes of this study, the PEL model projects changes in four key categories of state government expenditures: 1) SEPTA, 2) unemployment compensation, 3) income maintenance programs, and 4) health and human service programs.

State expenditures on SEPTA reflect the alternative scenarios. Costs of many state programs, including unemployment compensation, income maintenance, and health and human services, are affected by unemployment rates and population changes. Costs increase as greater numbers of jobs are lost (and unemployment increases), but go back down as some people eventually move out of the state. The nature of these changes in government expenditures are predicted by the fiscal impact model, based on regression studies of relationships of expenditures to changes in population, employment, and income changes over time.

Complementary Methods

The primary aim of fiscal impact analyses is to evaluate the degree to which revenue streams offset cost streams over the economic life of a project. If such a subsidy is required, the amount and duration should be evaluated in conjunction with projections of net economic benefits. These net benefits may be estimated using any of the quantitative methods described above, although the geographical scope of the economic estimates must correspond to the same jurisdictional boundaries used to estimate the net fiscal impacts.

Method's Score Card

The following score card grades the performance of fiscal impact analysis according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity			✓
External Validity		✓	
Reliability		✓	
Minimal Data and Resources	✓		
Transparency		✓	

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Miller, Alex J., and Michael D. Meyer. *Urban Transportation Planning – A Decision-Oriented Approach,* 1984.

Payne-Maxie Consultants and Blayney-Dyett. *The Land Use and Urban Development Impacts of Beltways: Comparative Statistical Analysis.* Prepared for the U.S. Department of Transportation, Washington, D.C., 1980.

Metrorail Fiscal Impact Studies (KPMG, 1985 and 1991.)

Method: Development Support Analysis

Description

Development support analysis combines physical conditions analysis, real estate market analysis, and interviews, and supplements these tools with an analysis of growth constraints related to highway capacity. This analysis focuses on the identification of the total square footage of development that could be supported by the improved transportation capacity provided by a transit investment. The analysis measures the number of additional trips that could access the study area without reducing the roadway level of service below a specified level. Then, using factors from the Highway Capacity Manual, the square footage of development by type that could be supported by this additional transportation capacity can be estimated. Factors for employment density per thousand square feet of space then can be used to calculate employment impacts. Methods used to measure specific impacts are described below:

Development Profile – Traffic analysis can be used to estimate the amount of development that could be supported by a transit investment. To conduct this analysis, land use mixes and densities are varied and entered into a traffic model until traffic volumes at street intersections result in a specified acceptable operating level of service, such as C (i.e., 80 percent of capacity).

When to Use

Development support analysis is used for predictive studies and can be used for MISs and EISs. It is also a useful tool to pinpoint sites for private sector participation.

Impacts Measured

Development support analysis can be used to measure redistributive and transfer impacts, including changes in corridor employment, square footage of development by type, property valuations, and property taxes.

Advantages

Development support analysis can be relatively low-cost. As for market analysis, however, data from private vendors can be expensive and may require substantial "number crunching" to use effectively. Development support analysis is one of the reliable approaches to estimating impacts of transit investments on real estate development at a station-area level, since it constrains build-out by highway service levels.

Disadvantages

Development support analysis requires a researcher experienced with real estate analysis. It can be particularly data demanding. Since development support analysis is a composite of four methods (i.e., physical conditions analysis, interviews, real estate market analysis, and transportation network modeling), it shares all of their disadvantages. It often hinges on numerous assumptions, not all of which are explicit, such as the likelihood of a station area reaching full build-out over a defined time line. There also must be consensus regarding assumptions, such as determining an acceptable level of service for a given roadway.

Data Sources

Development support analysis depends on real estate market analysis, and will utilize the same data sources listed under that method, above. Information on property values and current tax rates are available from local assessor's records. A transportation network model is necessary to identify the amount of development that can be supported while maintaining a specified level of service.

Example: The Transit Financing Study for the Massachusetts Bay Transportation Authority (MBTA) evaluated the transportation impacts in the South Boston Piers Area.[27] A significant consequence of Piers area development is a substantial rise in transportation demand. Such demand is projected to increase from roughly 7,000 peak-hour, peak-direction trips in 1986 to almost 20,000 by 2010; daily one-way trips are expected to increase from 80,000 to 180,000 during the same period. Although these dramatic increases are primarily due to overall development expansion, the shift from lesser traffic-generating land uses to others

[27] URS Consultants, Inc., et al., *Transit Financing Study: Final Report*, page 2-14 through 2-20, April 1991.

that generate much higher traffic has an amplifying effect on trip demand. For example, industrial uses generate substantially fewer daily one-way trips per 1,000 square feet of development than do office uses (1.8 and 6.7 trips, respectively). Thus, the shift from predominantly industrial uses – down from 63 percent of total development in 1986 to 28 percent by 2010 – to office uses – up from 25 to 45 percent during the same period – will create a parallel impact on the demand for transportation.

Even with the proposed roadway detailed in Section 2.2.1, trips generated by the proposed levels of development would cause severe congestion. Transit mode shares would be lowest in a no-action, surface-bus-only scenario – just 37 percent including transit riders to the CBD who then walk across the channel to access the Piers area – than in any scenario in which a transit improvement is made. Under the no-action scenario, the remaining high percentage of automobile trips – 63 percent – would create unacceptable traffic conditions in the Piers area and along Atlantic Avenue on the downtown side of Fort Point Channel. The BTD's Fort Point Channel/South Boston Roadway Study conducted under a state Public Works Economic Development grant, which also analyzed Piers area traffic conditions, documented even worse traffic congestion under a no-action scenario.[28] Thus, to alleviate this congestion and ensure that the 2010 land use goals can be achieved, the Commonwealth of Massachusetts has pursued the study of transit alternatives to serve the Piers area. The city and state are committed to building a transportation infrastructure that will capture 60 percent of peak hour trips on transit.

The 60 percent transit mode share goal reflects two major concerns of city and state policymakers. First, the capacity of the new regional highway system should not be overwhelmed by Piers area traffic demand. Transit can prevent such a situation by accommodating trips destined to the area. In addition, the abutting South Boston residential neighborhood must be protected from spillover transportation impacts. Second, regional economic growth can be better managed if the city serves as the focus for such growth. From a transit perspective, this second concern is supported by the MBTA's ability to better serve commuters to new jobs in Boston than to new jobs in suburban/exurban areas where transit is less competitive compared to automobile usage.

[28] Boston Transportation Department. Fort Point Channel/South Boston Roadway Improvement Study Compendium of Technical Memorandums, May 1989.

In an effort to create a transit environment consistent with these city and state policy goals, the impact of a parking constraint policy on traffic congestion was investigated. Analysis conducted for the DEIR suggests that a parking constraint policy similar to the one exercised in the CBD would be necessary to achieve the 60 percent transit mode share. With a slightly lower constraint on parking (such as that typified by the Kendall Square area), transit mode share in the peak hour drops by almost 6 percent. This loss in transit ridership translates to almost 1,000 additional person trips or 700 additional vehicle trips in the peak hour alone.

Analysis also demonstrates that unless parking is constrained and new transits services are provided, the development build-out for the Piers area should not be reached. Using traffic and mode share data developed for the DEIR, the level of service[29] (LOS at thirty key intersections in the project area was calculated assuming full land development and no additional transit service. Under the scenario, eleven of the thirty intersections failed (LOS F) in the P.M. peak hour. The land use assumptions were then incrementally reduced until no intersection experienced congestion worse than LOS D. This required an approximately 20 percent reduction in vehicular traffic, equivalent to the elimination of 20 percent of development across all land uses and geographic areas. Yet the LOS analysis showed that intersection failures would occur primarily in the western half of the Piers area. Thus, an equal elimination of development throughout the entire area may not improve traffic conditions in the already congested western end. To achieve an acceptable LOS in this western half, development levels may need to be reduced by more than 20 percent. Likewise, development in the less densely developed industrial eastern and southern section may not need to be reduced by 20 percent in order to achieve acceptable traffic conditions.

In general, however, this analysis indicates that the implementation of transit permits, at minimum, an additional 20 percent of development throughout the Piers area than would otherwise be possible. Only by implementing transit can full development take place in a manner that is sensitive to traffic levels and hence the environment. Therefore, since this additional increment of development is attributable to transit implementation, transit become the creator of value as measured by that 20 percent additional development.

[29] LOS measures range from A to F, with A indicating free-flowing traffic and F near gridlock conditions, in densely developed urban areas, LOS A to D is considered acceptable; the lower end of LOS E (40 seconds average delay) is also often considered acceptable. LOS F defines unacceptable traffic conditions with delays in excess of 1 minute and total signal cycle failure.

The existence of significant transit service already supporting the downtown area makes the application of such a transportation analysis difficult in that area. It is unlikely that the implementation of Transitway service between Boylston Station and the Piers area will permit any additional density in most downtown areas given existing zoning and development policies. Therefore, no increment of development density is assumed in the downtown area.

In industrial South Boston, development levels will also likely be unchanged by the Transitway; projected build-out for this area is assumed to be supportable by existing infrastructure. Thus, although no additional development density will necessarily accrue to the impact areas as a result of Transitway implementation, other benefits will be afforded; these benefits are documented in Chapter 6.

Complementary Methods

Development support analysis relies on physical conditions analysis, interviews, real estate market analysis, and transportation network modeling.

Method's Score Card

The following score card grades the performance of development support analysis according to five criteria described in Section 3.5.

Criteria	Low	Medium	High
Internal Validity			✓
External Validity		✓	
Reliability		✓	
Minimal Data and Resources	✓		
Transparency		✓	

Selected References

URS Consultants, Inc., et al., *Transit Financing Study: Draft Final Report.* Prepared for the Massachusetts Bay Transportation Authority, April 1991.

5.0 Guidelines for Selecting Methods for Economic Impact Analysis

This Guidebook includes a review of a wide range of methods used for conducting economic impact analysis of transit investments. Selecting the method most appropriate for an individual transit investment project requires that the agency or group sponsoring the analysis have a clear understanding of the reason(s) why the economic analysis is being conducted. These reasons, therefore, must be clearly communicated to the prospective researchers. This section identifies some of the most common reasons why economic impact analysis is performed.

5.1 Common Reasons for Conducting Economic Impact Analysis

The motivation for conducting economic impact analysis and the goals of the analysis will influence the choice of methods. This section describes seven common reasons for conducting economic impact analysis. For each reason, the types of impacts that might be of interest to the stakeholders and policy makers are identified. The information is summarized in Table 5.1. Table 5.1 can be cross-referenced with Table 4.1 (see Section 4.0) to assist the analyst with the selection of appropriate methods to meet his or her study objectives.

1. **Compare alternative transportation investments.**

   A community or state may want to compare the economic impact of alternative transit investments, or an investment in transit compared to investing in another public works project, or no investment at all. In these cases, the single methodology is applied to two or more investment scenarios, and the results are compared to identify which investment will result in the greatest positive economic impact. Because alternative investments likely will have different costs and benefits, analysts frequently use benefit-cost analysis to compare investments. User benefits normally make up the numerator of the benefit-cost equation. This type of benefit-cost analysis requires the conversion of travel time savings, safety benefits, and changes in operating costs into monetary terms, using standard conversion factors for value of time and costs of accidents by type of accident (i.e., fatal injury, nonfatal injury, and personal property damage.)

Table 5.1 Reasons for Conducting Economic Impact Analysis of Transit Investments

Reasons for Conducting Analysis	Typical Impacts of Interest
Compare alternative transportation investments	User benefits; construction, operating, and maintenance costs; generative employment and income growth; land development and redevelopment potential; increased economic activity; intra-regional employment and income shifts; tax impacts; opportunities for joint development.
Meet federal environmental review requirements	Employment and income growth related to construction, operation, and maintenance of the system; user benefits; generative employment and income growth; economic dislocation.
Stimulate corridor economic growth	Land development and redevelopment; intra-regional employment and income shifts; increased economic activity.
Secure long-term funding commitment	User benefits; net regional employment and income growth; external benefits; social benefits; tax impacts.
Encourage private participation	Reduced development costs; land development and redevelopment; increased economic activity; tax impacts; joint development opportunities.
Extend knowledge	User benefits; net regional employment and income benefits; agglomeration/urbanization benefits; external benefits; social benefits; land development and redevelopment; interregional employment and income shifts; increased economic activity; tax impacts; joint development income.
Win public support	User benefits; net regional economic and income growth; agglomeration and urbanization benefits; external benefits; social benefits; intra-regional employment and income shifts; construction/operations-related employment and income growth; tax impacts.

In recent years, several studies have expanded the benefit side of the equation to include the direct, indirect, and induced economic impacts of a transit project as its initial impact ripples through a local economy. Some studies also have tried to estimate economic impacts associated with the business expansion and attraction impacts that result from a transportation investment. To conduct these studies, analysts must supplement traditional techniques to measure user benefits with physical conditions analysis, interviews, and forecasting and simulation models to estimate the full effect of the economic impacts. The SEPTA Rehabilitation study is a good example of a study that employed this methodology.

2. **Meet federal environmental review requirements.**

Whenever federal funding is sought for a transit project, the project is subject to the federal environmental review process. The federal review process requires the completion of an MIS and an EIS. Both MISs and EISs have specific guidelines for the types of information that must be included, and economic analysis is one of the requirements. Federal regulations require the sponsoring agency to enumerate the generative impacts of the investment. In many cases, where the transit project can be justified solely on mobility and ridership criteria, analysts have taken a very narrow approach to defining economic impacts. Many studies have reported only the economic impacts of constructing, operating, and maintaining the system. These impacts frequently are measured using standard multipliers, and are presented in terms of changes in employment, output and personal income. The Tren Urbano Environmental Impact Statement (prepared for a transit investment in San Juan, Puerto Rico) provides a good example of the use of this methodology.

In cases where ridership and mobility impacts by themselves may not justify an investment in a new transit facility or when the mobility impacts are marginal, researchers sometimes rely on more sophisticated methods to identify the direct, indirect, and induced economic impacts of a transit investment. In these cases, analysts sometimes supplement the analysis of construction, operating, and maintenance impacts with an assessment of how the user benefits ripple through the regional economy. Benefit-cost analysis combined with input-output models and more sophisticated forecasting and simulation models measure these impacts over time, in terms of employment, sales, and output by sector, and personal income. The Environmental Impact Report for the Griffin Line proposed for Hartford, Connecticut is a good example of the use of a forecasting and simulation model for this purpose.

The federal environmental review process also requires that project sponsors identify any economic dislocation caused by the project. Economic dislocations generally involve businesses that must be relocated or closed because they are in the proposed right-of-way for the transit project or located at a proposed station site. For these impacts, researchers typically conduct a physical conditions analysis to identify affected businesses. One of two approaches is then used to estimate the number of jobs affected. The preferable approach is to interview representatives of the affected businesses to determine the number of people employed at the affected site. The second approach is to estimate employment at a particular site by first estimating the size of the facility affected (in square feet), and applying standard factors for the number of employees per thousand square feet for the type of business affected. The latter approach can produce errors since the number of employees per thousand square feet varies considerably among individual businesses. Virtually all environmental impact statements for transit projects include this type of analysis.

3. When one goal of an investment is to stimulate economic growth.

In recent years, interest has increased in the role of transit as a catalyst for economic development within a corridor or community. Several transit investment projects have been undertaken with an explicit goal of economic development (e.g., DART's South Oak Cliff line, the St. Louis Metrolink project.) When economic development is an explicit goal of a transit investment, analysts usually are aware that the majority of economic impacts will be redistributive, although generative impacts may also occur. All of these impacts typically are measured in terms of square feet of development, changes in employment and income, and changes in property values. Often, these studies rely on case comparisons, physical conditions analysis, economic base analysis, interviews, and real estate market analysis. In these cases, researchers should be clear that the impacts are redistributive, usually reflecting a shift of economic activity from elsewhere in the region to the proposed transit corridor. These studies should also include an assessment of supporting public policies (e.g., zoning changes, site assembly assistance, tax incentives) that should be put in place to encourage economic development in the corridor.[1]

4. Secure long-term funding commitments.

Funding for transit is subject to broad economic trends and political shifts. It is desirable, therefore, to secure a committed, continual stream of financial support for a transit system. This type of support usually requires state legislative actions that are subject to political pressures and public scrutiny.

Positive economic influences that can be attributed to a transit investment are a powerful political tool for gaining public and legislative support for transit. Several studies, therefore, have been undertaken to demonstrate the positive impacts of transit on employment, income, output, and tax revenues at both a local and statewide level. These studies utilize a variety of methods – including user benefits analysis, interviews, case comparisons, and forecasting and simulation models – to measure employment, output, and personal income impacts. Fiscal impact models generally are developed to measure a wide array of tax impacts including personal and corporate income taxes, property taxes, and sales taxes. Two examples of studies conducted for the purpose of securing financing for transit are the SEPTA economic impact study (The Urban Institute, June 1991), and the MetroRail fiscal impact studies (KPMG, 1985 and 1991).

5. Encourage private participation.

As competition among transit projects increases for limited funding, there also is an increased interest in encouraging private participation. To attract private dollars to transit project sponsors must convince private investors that a positive economic return will be realized on their investments. Investors may be interested in opportuni-

[1] See Parsons Brinckerhoff Quade and Douglas, Inc., *TCRP Report 16: Transit and Urban Form – Volume 2: Part III – A Guidebook for Practitioners, and Part IV – Public Policy and Transit-Oriented Development: Six International Case Studies*, 1996, for a discussion of supportive public policies.

ties for joint development, in which development costs are reduced due to cost sharing, or property values are increased (rent premiums are realized) as a result of locations near transit. Developers also may be interested in capitalizing on the reduced parking requirements at sites close to transit stations. These generative impacts usually are measured in terms of either the rent per square foot of development that can be charged, or the dollar return on investment that a developer can realize at a site served by transit versus a similar site without transit service. Case comparisons, physical conditions analysis, interviews, real estate market analysis, and development support analysis can all be used (generally in some combination) to measure these impacts.

6. **Extend knowledge.**

   Evaluative studies of the economic impact of transit studies often are conducted simply to further the body of knowledge about the economic impacts of transit investments. These studies generally identify differences in economic activity either in a transit corridor before and after construction of the transit facility (i.e., longitudinal analysis), or between a transit corridor and another study area that is similar to the transit corridor except that it is not served by transit (i.e., cross-sectional analysis.) These studies often employ regression analysis, statistical comparisons, or non-statistical comparisons to identify how a transit investment has affected economic activity within a transit corridor or region. For the most part, these studies focus on redistributive impacts, measured in terms of changes in employment, sales, output, personal income, business starts, and/or property values. Examples of this type of study include the BART impact studies (Grefe, et al., 1977) (Cervero, 1995; Landis et al., 1995.)

7. **Win public support.**

   In some cases, evaluative studies are conducted to convey to the public that a transit facility has resulted in positive economic benefits to a corridor or region. When this is the goal, some combination of methods such as interviews, physical conditions analysis, regression analysis, and statistical and non-statistical comparisons often are employed. The results of these types of studies tend to be used for public relations purposes. For example, in San Diego, evaluative studies were conducted using literature reviews, informant interviews, and benefit-cost analysis to demonstrate to the public that their investment in the light rail system had resulted in a positive economic return to the community.

Summary – Common Reasons for Conducting Economic Impact Analysis

The reasons for conducting economic impact analysis usually fall into one of seven categories:

- To compare alternative transportation investments;
- To meet federal environmental review requirements;
- When one goal of the investment is to stimulate economic growth;
- To secure continued funding for a transit system;
- To encourage private participation in a transit investment;
- To further the body of knowledge about the true impacts of a transit investment; and
- To win or maintain public support for a transit investment.

6.0 Critical Issues Affecting the Selection of Methods

A number of critical issues affect the selection and application of specific methodologies for estimating the economic impacts of a transit investment. This section provides a summary of the critical issues. Table 6.1 describes how each of the methods described in Section 4.0 addresses these critical issues. Because none of the methods adequately address every one of the critical issues, analysts often combine several methods when conducting economic impact analysis. This allows the analyst to identify the broadest array of impacts, and also provides a cross-check of results. The critical issues to consider when selecting economic impact methods include the following:

Data Requirements – This issue relates to the amount and complexity of data each method requires. Methods that require large amounts of data, or data that are not readily available, can be time consuming and expensive to use, although they often produce more rigorous results. Before selecting the method to be used, the sponsoring agency and the researchers should determine the availability of key data, that the data are complete, and the cost of the data. Data should be reviewed to determine whether they can be used immediately, or whether substantial work will be required to put the data in a usable format. Reviewing the availability and condition of data prior to selecting methods can save substantial time and money and can ensure that the selected methods can be used.

Skill Level of Analyst – The level of technical expertise required to conduct economic analysis is directly related to selecting appropriate methods. While some understanding of economic relationships and/or factors influencing land development are necessary for utilizing all of the methods described in this document, the degree of technical expertise required varies considerably among methods. Therefore, the sponsoring agency needs a clear understanding of the capabilities of the analyst assigned to conduct the study before selecting methods.

Technical Requirements –To match the skills of the analyst with an appropriate methodology, the sponsoring agency must also understand the technical complexities of alternative methods. Many of the more rigorous methodologies require the use of complex modeling procedures and tools. As with data requirements, these models can produce high quality results, but also can be costly and time-consuming, and require that the analyst have substantial technical skills.

Cost – Certain methods are more costly than others. Cost generally corresponds to the complexity of the method (e.g., more complex methods are more expensive than simple methods.) Certain simple methods, however, may rely on data inputs that must be derived through costly procedures. It is useful for the sponsoring agency to have at least an "order of magnitude" understanding of the costs associated with alternative methods before embarking on economic impact analysis. It is also important that the sponsor

Table 6.1 Critical Issues and Economic Impact Analysis Methodologies

	Regional Transportation – Land Use Models	Input-Output Models	Forecasting and Simulation Models	Multiple Regression and Econometric Models	Non-Statistical and Statistical Comparisons	Case Comparisons	Interviews/ Focus Groups/ Surveys	Physical Conditions Analysis	Real Estate Market Analysis	Fiscal Impact Analysis	Development Support Analysis
Case Study Systems											
SEPTA	X		X							X	
WMATA		X				X	X			X	
South Boston		X				X				X	X
St. Louis						X	X	X	X		
Portland	X	X		X			X	X			
San Diego	X	X			X		X	X		X	
Critical Issues											
Data Requirements	Requires transportation network with volumes, speeds, and travel time between links.	Analyses typically rely on commercially available models, so no additional data collection is needed.	Analyses typically rely on commercially available models with default data included. Area-specific data may be added. Also requires data from travel; time savings analysis.	Extensive data needed for both transit-related and non-transit-related factors to clearly identify relationships. Very data intensive.	Relies on a variety of data (defined by the question the researcher is interested in), but typically used when insufficient data exist to support multiple regression analysis.	Matched pairs (study area and control area) may not exist. The type of data required will depend on what the researcher is interested in analyzing. Data such as property values over time can be difficult to obtain.	No specialized data required.	Requires collection of information on existing land uses, building conditions, vacant land, and other items. Can be time-consuming to collect data.	Data is not available from a single source. Real estate information (e.g., lease rates) varies on a site by site basis, and can be difficult to generalize.	Relies on district-specific tax information for all taxes levied on properties within the study area. May require output from real estate analysis or case comparisons.	Estimate of development demand in square feet by specific land use. Information on travel demand associated with new development (generally derived from a travel demand model). Data on level of service on roadways in the study area.
Technical Requirements	Typically requires use of travel demand and network simulation models to estimate travel time savings, safety benefits, and changes in operating costs attributable to transit.	Generally uses standard input-output models (i.e., models already developed at the state or regional level).	Requires use of complex econometric models.	Statistical and econometric computer models required.	Statistical modeling may be required.	Statistical methods/regressi on analysis typically used.	May utilize statistical methods to analyze data.	None.	Spreadsheet models to estimate demand may be used.	Usually requires that a spreadsheet-based model be built.	Requires use of network traffic model (and, ideally, travel demand model) to estimate the maximum amount of additional development that could occur, with transit in place, without degrading roadway LOS.

Table 6.1 Critical Issues and Economic Impact Analysis Methodologies (continued)

	Regional Transportation – Land Use Models	Input-Output Models	Forecasting and Simulation Models	Multiple Regression and Econometric Models	Non-Statistical and Statistical Comparisons	Case Comparisons	Interviews/ Focus Groups/ Surveys	Physical Conditions Analysis	Real Estate Market Analysis	Fiscal Impact Analysis	Development Support Analysis
Critical Issues (continued)											
Cost	If travel demand and network simulation models are available, method is inexpensive. Developing and calibrating the models usually is very expensive.	The cost of commercially available models varies. Generally not expensive.	The cost of commercially available models varies. May be too expensive for some agencies.	Cost depends on availability of data, and the time required to develop the model.	Not expensive, provided necessary data are available.	Expense tied to availability of data.	Expense depends on complexity and number of surveys/focus groups/interviews to be conducted, and intended use of responses (e.g., if responses are to be used for statistical analysis, expense is greater).	Generally not expensive, except in cases where data collection is very difficult or time-consuming.	Generally not expensive, except in cases where data collection is very difficult or time-consuming.	Not generally expensive, provided data are available.	Not expensive if necessary transportation models are available and calibrated to the study area. If model calibration is required, can be very costly.
Skill Level of Analyst	Developing and using travel demand and network simulation models requires a high level of technical expertise. If the models already exist, converting time savings and safety benefits to a dollar value does not require substantial technical skills.	Best performed by an analyst with some economics background, but can be used by others.	Varies based on how the model is being used. A strong economics background is necessary in order to make sure that modeling results make sense. Some model developers will run the model for clients, requiring no specific skills of the researcher.	Requires sound knowledge of statistics. Proper application also requires sound knowledge of research design.	Statistical comparisons require basic knowledge of statistics. Non-statistical comparisons do not require specialized technical skills or knowledge.	No specialized technical skills required.	For best results, a skilled facilitator and/or someone trained in market research methods should participate in applying these methods.	Requires careful, systematic approach to collecting data, but no specialized technical skills.	Requires sound knowledge of real estate markets.	Requires an understanding of public finance, and an ability to construct complex spreadsheets.	Developing and running network traffic models and travel demand models requires specialized knowledge and skills. Using the model results to assess alternative development scenarios does not require substantial technical skills.

Table 6.1 Critical Issues and Economic Impact Analysis Methodologies (continued)

	Regional Transportation – Land Use Models	Input-Output Models	Forecasting and Simulation Models	Multiple Regression and Econometric Models	Non-Statistical and Statistical Comparisons	Case Comparisons	Interviews/ Focus Groups/ Surveys	Physical Conditions Analysis	Real Estate Market Analysis	Fiscal Impact Analysis	Development Support Analysis
Critical Issues (continued)											
Ability to Isolate Impacts	Can estimate the travel time savings, safety benefits, and changes in operating costs and associated monetary benefits attributable to a transit investment.	Can estimate both macro-economic changes and industry-specific changes (e.g., employment, income, productivity) stemming from the construction, operation, and maintenance of a transit system, and/or from the travel time savings the system produces.	Can estimate macro-economic changes (e.g., employment, income, sales) stemming from the construction, operation, and maintenance of a transit system, as well as business expansion and attraction benefits.	If adequate data exist, regression analysis can effectively isolate impact of transit investment from non-transit factors.	Not able to isolate impacts quantitatively.	Cannot quantitatively isolate transit-related impacts.	Cannot quantitatively isolate transit-related impacts. Can provide qualitative information on impact of transit investment.	Cannot quantitatively isolate transit-related impacts. Can provide qualitative information on impact of transit investment.	Generally used to assess whether market conditions would support new development. Can be used to quantify square feet of potential development, and to derive employment at this development.	Isolates tax (i.e., transfer).	Can estimate the amount of additional development that could occur, with addition of transit, without degrading roadway LOS. By default, method controls for non-transit factors, by assuming that they remain constant.
Transparency of Method vs. Complexity of Results	Details of the travel demand and network simulation models are highly complex. Aspects of the benefit/cost analysis (e.g., discount rate and analysis period) can also be difficult to explain to the layperson.	Details of the I-O models are highly complex. However, communicating the "bottom line" impacts is not difficult.	Details of the models are highly complex, and the model is frequently viewed as a "black box." Thus, consumers are sometimes skeptical of results. Output from the models can be easily communicated.	Method and results can be difficult to explain to people without knowledge of statistics.		Method is easy to explain, but produces simple, largely qualitative information.	Method is easy to explain, but produces simple, largely qualitative information.	Method is easy to explain, but produces simple, largely qualitative information.	Method relies on "expert judgment," which can raise questions about its validity. Results are generally easy to understand.	Method is straightforward and easy to explain.	Details of the models are highly technical, but the overall approach is easy to explain, and produces clear results.

Table 6.1 Critical Issues and Economic Impact Analysis Methodologies (continued)

	Regional Transportation – Land Use Models	Input-Output Models	Forecasting and Simulation Models	Multiple Regression and Econometric Models	Non-Statistical and Statistical Comparisons	Case Comparisons	Interviews/ Focus Groups/ Surveys	Physical Conditions Analysis	Real Estate Market Analysis	Fiscal Impact Analysis	Development Support Analysis
Critical Issues (continued)											
Time Required for Application	Not time-consuming if model results are already available. Developing, calibrating, and running models can be extremely time-consuming.	Not time-consuming once model is calibrated to the study area.	Can be time-consuming if model is to be used to identify business expansion and attraction impacts. Not time-consuming to estimate multiplier impacts of construction, operation and maintenance.	Data collection is very time-consuming.	Data collection is time-consuming.	Generally not time-consuming, once comparison systems are identified.	Can be time-consuming to identify and schedule participants, and to disseminate findings (particularly if quantitative results are sought.)	Can be time-consuming if study area is large or complex.	Can be time-consuming if study area is large or complex.	Can be very time-consuming to collect data and build model.	Generally not time-consuming, provided models are available.
Ability of Method to Differentiate Between Generative, Redistribute, and Transfer Impacts	Monetary benefits associated with reduced travel time, safety benefits, and changes in operating costs are generative impacts.	Can be used to measure both redistributive/ transfer impacts (e.g., construction-related impacts) and generative impacts.	Can be used to measure both redistributive and generative impacts.	Can be used to measure either redistributive or generative impacts.	Can be used to measure either redistributive or generative impacts.	Cannot quantitatively differentiate between various types of impacts. Can provide qualitative information on the types of impacts transit investment produced.	Cannot quantitatively differentiate between various types of impacts. Can provide qualitative information on the types of impacts transit investment produced.	Generally measures redistributive impacts. Cannot distinguish between redistributive and generative impacts.	Redistributive impacts.	Measures redistributive/ transfer impacts.	Cannot determine whether additional development would represent net economic growth, or redistribution of existing economic activity.
Scale of Analysis (e.g., region, corridor, station area)	Can be used at regional or corridor level.	Generally applicable at regional or state level.	Generally applicable at the metropolitan and state levels. Typically not available below county level because of data constraints.	Applicable at any scale for which adequate data exist.	Applicable at any scale for which adequate data exist.	Best suited to corridor or station area analysis.	Applicable at any scale.	Applicable at corridor or station area level. Not practical at larger scales.	Best suited to corridor or station area analysis.	Applicable at regional level.	Best suited to a discrete study area, and to specific roadways and intersections.

understand that a researcher can be found to conduct an economic impact analysis for almost any price; however, as with any research, the results of a poorly funded study will not be as dependable as those produced from a well funded effort. Clearly, the goal of the study and the importance of economic impacts to that goal will strongly influence the level of funding for the analysis.

The Interests and Needs of Stakeholders – When selecting a method or methods for conducting economic impact analysis, it is critical that the sponsoring agency and the researcher identify the stakeholders and policy makers who will use the economic impact analysis results, as well as their interests and needs. The potential range of stakeholders for a given transit investment is quite large, and includes taxpayers, legislators, public officials and employees, the federal government, land owners, developers, residents, the transit agency, and special interest groups (such as environmental groups, transit-dependent groups, etc.). The individual interests of these groups will vary considerably. For example, a developer will be interested in how the transit investment will impact his or her specific development parcel, residents may be concerned with both impacts on particular parcels and community-wide impacts, and taxpayers may be interested in community-wide property tax implications of the investment. Because different methods are used to measure different impacts, it is imperative that stakeholders and their interests be identified up front. The interests and needs of the stakeholders will influence the methods selected, the impact measures, and how the impacts are presented.

Ability to Quantify Variable(s) of Interest – Not all methods can be used to measure the same impacts, and some impacts are difficult to quantify. For example, a transportation network model is required to quantify user benefits, while regional economic impacts such as changes in personal income or changes in output by sector require the use of I-O models or economic forecasting and simulation models. It is critical that the analyst first identifies the impacts of interest to decision-makers, and then selects methods that can quantify these impacts.

Analysis Period – The analysis period refers to the time period over which impacts will be measured. The selection of the analysis period depends on the purpose of the economic analysis. For example, for a benefit-cost analysis, the period must cover the construction period as well as several years of operation, since benefits do not begin to accrue until after the facility is operational. For this type of analysis, the analysis period ranges from 20 to 30 years. For before and after studies of the impacts of a transit investment, the analysis period must be long enough so that the impacts of the transit investment have materialized. After the initial BART Impact Studies, researchers determined that the studies were conducted before enough time had passed to realize the full impacts of the investment. Therefore, the BART @ 20 study was undertaken to identify if the impacts increased with the passage of time.

Ability to Isolate Transit-Related Impacts – Some methodologies are able to isolate the economic impacts of a transit investment from the myriad other factors that can influence economic activity, while others cannot provide this type of information. Generally, methods that can isolate impacts are more costly, require more data, and are more technically demanding than methods that cannot specifically isolate transit-related impacts.

Transparency of Method vs. Complexity of Results – There is frequently an inherent tradeoff between a method's ability to produce detailed, complex results, and the ease with which the method can be explained (especially to non-technical audiences). While a talented presenter should be able to explain the basic concepts of more complex methods to non-technical audiences, the mechanical details of the more rigorous methods may not be suitable. Nevertheless, simple methods usually have easily identifiable shortcomings and are therefore more open to attack. The more complex the method, the more rigorous the results and – perhaps more importantly – the more revealing the answers.

Time Required for Application of Method – Different methods require different amounts of time to apply. Generally, the more complex and quantitative methods require the most time, as they require substantial data collection and preparation, and may require the development of a computer model. The more time-consuming approaches tend to produce more detailed and reliable results. This relationship, however, has notable exceptions. Interviews and focus groups, for example, can take significant time to set up, conduct, and summarize, especially when the results must be comprehensive. A special study using the REMI model, on the other hand, may take two weeks to complete.

Ability of Method to Differentiate Between Generative, Redistributive, and/or Transfer Impacts –As noted in the descriptions of methods, each of the methods described in this Guidebook measures specific types of economic impacts. The analyst must first identify the type(s) of impacts important to the goals of the analysis (i.e., generative, redistributive, and/or transfer), and then must select methods that specifically measure those impacts.

Scale of Analysis – Certain methods (e.g., modeling-based approaches) are best suited to regional-scale or county-level analyses, while other methods (e.g., physical conditions analysis real estate market analysis) work best at the corridor level or at an even smaller scale. For measuring generative impacts, a scale of analysis below the county level may not be appropriate regardless of what method is used.

Summary

When selecting methods for conducting economic impact analysis of a transit investment, several issues must be considered. These include:

- Data requirements versus availability;
- Skill level of the analyst;
- Technical requirements;
- Cost;
- Interests and needs of the stakeholders;
- Ability to quantify variable(s) of interest;
- Analysis period;
- Ability to isolate transit-related impacts;
- Transparency of methods vs. complexity of results;
- Time required for application of method;
- Ability of method to differentiate between generative, redistributive, and transfer impacts; and
- Scale of analysis.

It is also critical to develop an understanding of the political climate in which the analysis is being conducted. Is there support for the investment? How important is the economic analysis to the decision-making process? How closely will the results be scrutinized? The answers to these questions will help to determine how rigorous the analysis must be, how the results should be presented, and which methods are most appropriate for the situation.

7.0 Evaluating the Results of the Economic Impact Analysis

When the economic impact analysis is completed, the results should be evaluated to identify the strengths and shortcomings of the analysis. In particular, it is important to review the analysis and results from the viewpoint of those who are opposed to the project. By reviewing the analysis from the viewpoint of the opposition, the sponsoring agency can identify key findings or methods that will be criticized, and can prepare responses to these criticisms in advance. The following questions should be asked when reviewing the study methods and results.

1. **Are the results believable?** Are they within the range of magnitude of impacts that have been identified for similar projects? Case comparisons provide a good barometer for assessing the validity of the results. If some results seem smaller or larger than might be expected, are there identifiable and justifiable reasons for these anomalies?

2. **How reliable were the data used in the analysis?** What data were missing and how did the analyst adjust for the missing data? Are the adjustments appropriate? Were data collected in a consistent manner? Are there any fatal flaws in the data or the methods? For example, were data from different sources, different years, or different geographic areas mixed together? Using data from different sources can be particularly problematic because, while they often appear to represent comparable information, differences in how data are defined or collected can mean that the data are not comparable.

3. **What were the critical assumptions used in the analysis?** For example, if a benefit-cost analysis was performed, assumptions such as the construction period, the analysis period (e.g., 20 or 30 years from the start of construction), and the discount rate will all impact the results significantly. Are the assumptions reasonable? An example of an unreasonable assumption would be a three percent discount rate or a one-year construction period for a new start project. The federal General Accounting Office and the Office of Management and Budget can provide guidelines for appropriate discount rates.

4. **Are assumptions and data inputs reasonable and well documented?** Studies sometimes include assumptions such as, "property values within 1/4 mile of the transit stations will grow at 1.3 times the average for the area." It is critical to document the sources of assumptions to the degree possible because they always draw scrutiny from opponents of the transit investment. If they appear to be unreasonable, the entire economic impact analysis can be undermined. Predicting future rates of growth always will incorporate some assumptions, and it is important that researchers explicitly document them.

5. **Has sensitivity analysis been performed to identify the impacts of small changes in key assumptions and other data inputs?** Sensitivity analysis is an important component of economic impact analysis because it is very difficult to predict the future with accuracy. Sensitivity analysis allows decision-makers to understand both the upside and downside of the investment, and to make the investment decision with a clear sense of the economic risks involved. Sensitivity analysis might include using two different discount rates for benefit-cost analysis, or two different growth factors for property values in the vicinity of the transit station.

6. **Were alternatives evaluated equally?** It is not unusual for a sponsoring agency to begin an economic impact analysis with a clear preference for a particular investment alternative. Nevertheless, it is critical that each alternative be evaluated using parallel methods and comparable rigor. If the evaluation of alternatives is not comparable, critics will be quick to undermine the results of the study. In addition, decision-makers will not have sufficient information to evaluate the alternative investment decisions.

7. **Were exogenous factors that might impact the results identified and evaluated?** For example, it might be appropriate to identify factors such as potential changes in gasoline prices, emissions standards, tolls, or telecommuting behavior, and at least suggest how these factors might influence the study results. Some techniques, such as econometric analysis, explicitly incorporates such factors directly into the analysis.

8. **Is sufficient documentation provided to allow interested parties to understand how the analysis was conducted, the methods used, and the assumptions?** Too often, economic impact studies are not accompanied by technical appendices or other documentation describing how the analysis was performed. This deficiency makes it difficult for interested parties to evaluate the rigor of the study. Insufficient documentation also will make it difficult for sponsors and proponents to respond to criticism. Furthermore, project sponsors may find it impossible to replicate the methods for other alternatives.

9. **Are the types of economic impacts measured (i.e., generative, redistributive, and financial/transfer) clearly and accurately identified?** If impacts are redistributive, does the analysis make clear that the economic gains within the corridor represent a shift of economic activity from elsewhere in the region? Results must be clearly explained, both in the executive summary, as well as in the technical appendices.

10. **Does the analysis avoid double-counting?** Decision-makers may wish to see the same impacts measured in different ways. For example, it might be appropriate to identify both the monetary value of travel time savings, as well as how these savings are capitalized in changes in property values. While it may be appropriate to report both of these findings, it would be inappropriate to add these impacts together, since they represent two different measures of the same impact. It is critical that the analyst avoid double-counting. In addition, whenever more than one measure is presented for a single impact, the analyst should clearly identify these measures, and state that they should not be added together.

11. **Does the analysis avoid sample bias?** Sample bias can be a problem in any type of social science research, and may occur for any number of reasons. For example,

sample bias can occur when interview, survey, or focus group participants are selected who all represent the same viewpoint. Similarly, sample bias can occur when communities are selected for case comparisons that are not comparable to the study area.

12. **Is the analysis externally valid?** Can the results of the analysis be generalized beyond neighborhood boundaries to apply to the broader region, or are the impacts specific to a single neighborhood or corridor? The degree to which the results of the analysis can be more broadly applied should be clearly stated and supported.

13. **Are the results presented appropriately for the target audience?** Can key findings be presented so they are transparent and understandable to decision-makers and the public? Are the findings that are presented appropriate for helping decision-makers with the evaluation of the investment decision?

Summary

The economic impact analysis and results should be evaluated for the following:

- Believability of results;
- Reliability and quality of data;
- Accuracy of assumptions;
- Source and accuracy of data inputs;
- Sensitivity of results to changes in assumptions and data inputs;
- Degree to which alternatives were evaluated equally;
- Impact of exogenous factors on results;
- Documentation of methods, data sources, assumptions, etc.;
- Clear identification of the types of impacts measured;
- Avoidance of double-counting;
- Sample bias;
- External validity; and
- Transparency of results.

8.0 Presenting the Results of the Analysis

Economic impact analysis may result in important findings that can shape transit investment decisions. To be most useful, these findings must be communicated effectively to stakeholders and policy makers. Because both the methods and the results often are complex and somewhat technical, effective communication of the relevant findings requires careful consideration and planning. This section describes five important steps for effective communication of the economic impact analysis findings.

1. **Know your audience(s).** Enough cannot be said about the importance of knowing the interests and needs of the consumers of the information to be presented. For any study, there may be several different audiences for the information, ranging from corridor residents to state legislators to university economists. The type of information of interest to each group may differ. Furthermore, the presentation of the material also will need to be tailored to each group's interests and technical expertise. Presentations of discount rates and regional product coefficients, for example, will be too technical for many audiences whose primary interest may be a bottom-line figure for the expected change in corridor employment or property tax revenues. Others, such as potential financing partners, may well be interested in more detailed information, such as what discount rate was used for a benefit-cost analysis, how it was selected, and the results of sensitivity analysis using different discount rates. By developing a clear understanding of the interests and sophistication of the audience prior to presenting the results, the researcher or sponsoring agency can ensure that the measures of interest are presented at the appropriate level of detail and help the presenter to anticipate questions.

2. **Use an executive summary to provide clear and concise information.** It is the rare citizen or public official who will read long, technical documents describing the findings of an economic impact study. A clear, concise executive summary provides the best tool for distilling sometimes complex information into a format that is readable and will be read by the public. An executive summary that includes a brief discussion of the methodology used for the analysis, a synopsis of key assumptions, and a short description of key findings will not only reach the greatest number of stakeholders, but also will guard against erroneous interpretations and misrepresentation of technical materials. The executive summary should provide a balanced summary of all key results, and should clearly reference sources such as technical documents where interested parties can find more detailed information about the analysis.

3. **Use clear, simple graphics for presentation purposes.** Material presented at public forums, stakeholder meetings, or presentations to policy makers should be of professional quality, uncluttered, and simple. Graphics should focus on the bottom line findings of the analysis, with limited emphasis on methodological issues. Bar graphs

and pie charts have proven to be particularly effective tools for presenting changes in employment, income, and property taxes, particularly when comparing among alternatives. The comparison of alternatives – even when the only alternative is a no-project scenario – is one of the most informative methods of presenting complex results. The viewer's attention is focused on the difference between investments rather than the absolute impacts of a single scenario. Graphics also provide an effective tool for communicating the results of sensitivity analysis. Graphics will be duplicated in the press. They must be unambiguous and self-explanatory. Few staff reporters of local newspapers can be counted on to accurately interpret complicated graphics for their readers.

4. **Make available technical documents that provide more detailed information about methods and key assumptions.** While most of the consumers of the economic impact analysis results will not be interested in the detail behind the executive summary, some stakeholders will want to review the analysis methods and assumptions in more detail. It is important that technical documents are prepared that clearly explain the methodologies employed for the analysis, and, more importantly, document the sources of data and key assumptions. Failure to document the sources of or reasoning for selecting key assumptions will be interpreted by opponents of the analysis as weaknesses to be pursued.

5. **Clearly identify study constraints.** Policy makers and stakeholders need complete information when evaluating the merits of major investments such as transit facilities. It is not only important to present analysis findings, but also to document critical constraints that affect the analysis. Issues such as data limitations, budget shortfalls, limited timeframe for conducting the analysis, shortcomings of the selected methods, and other weaknesses of the analysis should be documented. The potential impacts of these limitations on the analysis results should be acknowledged. While constraints should be acknowledged, they should be presented so as not to undermine the study results.

Summary

The following guidelines should be used to present the economic impact analysis results:

- Know your audiences and the information that will be of interest to them;
- Present information in an executive summary format;
- Use clear, simple graphics for presentation purposes;
- Make available technical documents that detail methods, assumptions, and results; and
- Identify study constraints, and how the constraints may impact the results.

9.0 Selected Nontraditional Benefits

The following two sections present two methods for measuring benefits which traditionally have not been included in economic impact analysis. Section 9.1 describes benefits of reduced parking requirements due to the availability of transit. Section 9.2 describes transit-induced accessibility and agglomeration benefits. Both benefits can be substantial relative to the other types of benefits described in the previous sections of this Guidebook, as well as in absolute terms, especially over the life of the project. The reasons analysts omit these benefits vary, but the uncertainty of how to measure them probably contributes to this omission. The measurement methods themselves are not new; rather, their application and adaptation to measuring these specific benefits is unfamiliar to many analysts. Sections 9.1 and 9.2, therefore, devote considerable attention to explaining measurement methods and their correct application under a range of different conditions.

■ 9.1 Measuring Benefits of Reduced Parking Requirements

Introduction

Today, parking is as essential to a development project as are an entry lobby, elevators, and hallways. All of these facilities connect the user to an office, living room, or favorite coffee shop. While they are essential parts of the ultimate "usable" space (i.e., office, home, or shop), and account for a significant share of a building's cost, such facilities do not generate rent directly. The developer must balance the size and quantity of these non-revenue producing facilities against their cost and contribution to the success of a total project.

Since building and zoning codes specify minimum requirements for the size of entry lobbies, number of elevators, and number of parking spaces provided, the developer must decide whether to meet or exceed the minimum requirement. If a development project adjoins a convention center or a city park, a developer may sometimes undersize the common spaces since tenants have ready access to these public places. Such a substitution of public goods for private investment generates a benefit to the developer which, depending on other market conditions, may be necessary to make a project cost-effective, generate a windfall to the developer, or be passed on to tenants and sometimes to the general public. The same type of substitution occurs when private development can be accessed by public transit. When road capacity is at its limit, public transit can increase accessibility to the development. Transit, therefore, has the potential to supply a development with workers and customers. More importantly, as more people access a development by public transit, transit may act to reduce demand for parking, thus reducing the number of parking stalls a developer needs to provide at the project's expense.

While parking reduction usually represents a benefit, estimating the size of the benefit and determining who ultimately receives it is not usually a straight-forward calculation. Finding the answers involves understanding the market and other forces in effect within a specific project area. These forces may be grouped into the following three categories:

1. **The requirements (supply) and demand for parking.** National surveys and case studies indicate that, in many areas of the United States, minimum parking requirements exceed demand by a considerable amount. While this is especially the case in suburban employment centers, many rapidly growing urban areas and central business districts (CBD) that currently do not have fixed guideway transit service also are oversupplied. Furthermore, these surveys report that developers usually build only the minimum amount of parking required.[1] Thus, a reduction in parking may involve two components: the first to eliminate the over supply and the second to account for transit ridership.

2. **The real estate market and the allocation of benefits.** The strength of the market determines who benefits from a reduced parking requirement and by how much. Low vacancy rates, high rents, scarce land, and a lack of alternative locations are usually good indicators of a strong real estate market, which would enable a developer to substitute leasable space for parking. If the developer had not yet purchased land for a project, these benefits may be captured by the land owner in higher land costs. In a weaker market, the developer likely would not replace the foregone parking with leasable space, thus the developer would simply not buy the land needed for the excess parking. In this weaker market, however, either the developer will benefit through lower land acquisition costs, or tenants might benefit from lower rents.

3. **The cost and price of parking.** The construction cost of parking depends on the type of parking being built. There are three types of parking (given in order of increasing cost): surface parking, multilevel or structural parking, and underground parking. As the cost of land increases, developers will use land for leasable space, and construct the more costly types of parking. The vast majority of surface parking is located in suburban job markets where land is relatively inexpensive compared to urban markets. In urban markets – especially in CBDs – developers must pay very high prices for raw land. In these markets, developers may choose to construct underground parking, which can cost between five to 10 times as much as surface parking, because they can recoup the cost of the parking through premium rents for leasable space.

This remainder of this chapter describes how to estimate the benefits of reduced parking at developments in the vicinity of transit stations within the context of the market forces described above. It provides a general methodology based on real estate pro forma analysis. An analyst must then apply the methodology to a specific development project or a

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[1] Richard Willson, "Suburban Parking Requirements," *Journal of the American Planning Association*, Vol. 61, No. 1, Winter 1995.

particular study area to estimate the net benefits of reduced parking. In addition to the estimation of direct benefits, this section provides an overview of second order effects of reduced parking.

Estimating Parking Requirements from Demand

This section describes how an analyst may estimate parking requirements for urban versus suburban land use and areas with or without transit service. The general methodology is intended to determine how much parking really is required given likely demand. This analytic approach is essential if an analyst is to calculate a demand-based estimate of maximum parking requirements. The methodology presented is generic and therefore must be refined when applied to a specific transit project. Some important refinements involve adapting the methodology to the type of environment in which the project is planned: suburban, urban, or high density CBD.

The vast majority of parking requirements are based on zoning codes that have been written with only vague understanding of actual demand and little or no regard for an area's specific characteristics. Zoning codes in areas not served by transit typically require between 3.0 and 5.0 spaces per 1,000 gross square feet (gsf), with the lower end of the range for urban areas and the higher end for suburban areas. Surveys of both highly dense urban markets and low-density suburban markets revealed a common standard of approximately 4.0 spaces per 1,000 gsf, often without regard to building type.[23] In a survey of 117 urban and suburban jurisdictions in Southern California, for example, researchers calculated an average of 3.8 spaces per 1,000 gsf (the median was 4.0 spaces per 1,000 gsf).[4] Many local jurisdictions adopt this universal standard to avoid the administrative complexity and the expense of conducting comprehensive parking demand studies.[5]

Nevertheless, sophisticated methods are used to estimate parking demand for large developments or areas where parking is scarce, expensive to provide, and the opportunity cost of land is great. Where transit exists, these methods often include detailed studies of the effects of transit service on parking demand. Although each situation requires some variation in methods, Figure 9.1 presents a general approach as a basis for estimating parking demand from a specific activity.

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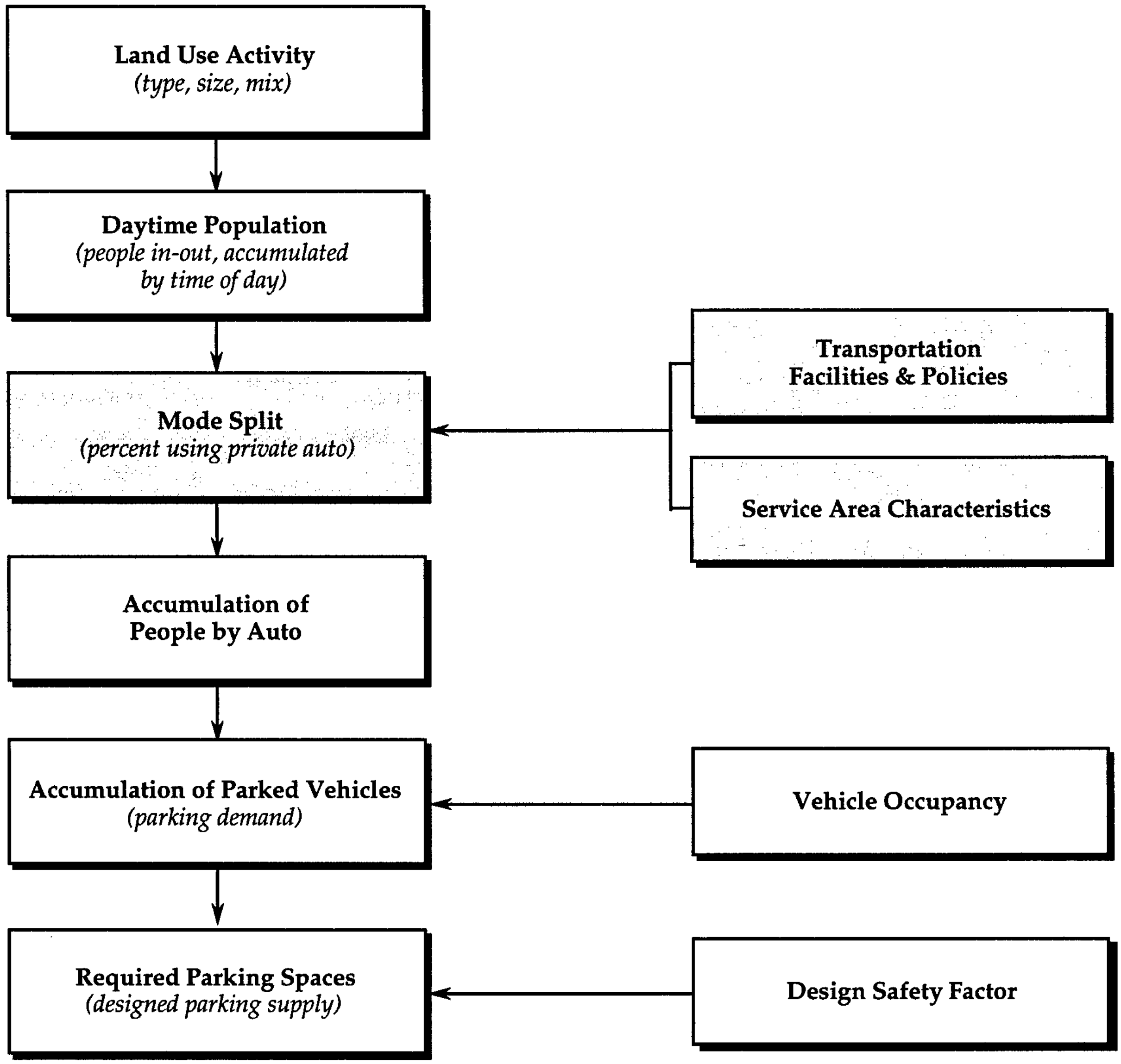
[2] Bergman, 1991; Gruen Gruen & Associates, 1986; *International Parking Design*, 1988; Cervero, 1984; Cervero, 1989; Shoup, 1993).

[3] Many cities that are well-served by transit have much lower parking requirements, particularly in their CBDs. For example, in Boston, developers are required to provide only 0.3 parking spaces per gsf of office space. In New York City, only 0.25 spaces are required per gsf of office development.

[4] An analysis of five special suburban office developments in five Southern California counties found an average requirement of 2.9 spaces per 1,000 gsf. Study authors deliberately selected jurisdictions with lower than average parking requirements. The average requirement for the five case studies in typical jurisdictions was 4.1 spaces per 1,000 gsf. (Willson, 1995).

[5] Reed, C. 1984, *The Zoning Report* 2:1-8.

Figure 9.1 Estimating Parking Demand



Source: Robert Weant and Herbert Levinson, *Parking*, 1990, p. 93.

The process outlined in Figure 9.1 may be organized into two parts. The first, shown in the first four steps, provides an aggregate estimate of the person-accumulations (number of visitors and employees per square foot) generated by each type of land use for peak periods of activity. This aggregate is made up of separate estimates for each population group with dissimilar parking characteristics (i.e., length of stay, trip purpose, and inclination to use transit based on socioeconomic characteristics). These estimates depend on the mode split of the population, which are influenced by the transportation system and the characteristics of the transit service area. An investment in transit should not only decrease the number of vehicles accessing the development, but theoretically will induce more person trips to the area by attracting people who will only come via transit.

The second part of the process converts the person-accumulation estimates into a peak-hour accumulation of parked vehicles, given average vehicle occupancy rates and number of person trips. For multiple-use projects, separate estimates for peak-hour demand by land use type must be subtotaled to determine the aggregate peak-hour parking demand. This total parking demand is based only on demand generated from primary land uses. While there may be some complementary effects, secondary attractions derive most of their business from the draw of the primary activities (e.g., employment centers; major entertainment – movies, theater, stadium, etc.; regional retail; etc.); thus, the secondary uses (e.g., restaurants, news stands, business services, etc.) are not counted.[6]

In Figure 9.1, **Mode Split** is shown as an outcome of **Transportation Facilities and Policies and Service Area Characteristics**. Both of these are affected by the level of transit service. Although the expected influence on mode split must be determined through careful survey and model development, new or improved transit service within a specific area generally is expected to increase transit mode split and decrease demand for parking for the area. This area-wide change in mode split – and a corresponding decrease in parking demand – provides the basis for a reduction in parking requirements.

The specific number of spaces that can be omitted when transit provides good access to a development site requires a reasonably detailed analysis. This analysis must be tailored to a specific development project. Alternatively, it can be applied to a geographic area that is comprised of sites with similar transit characteristics. The following generic formula can serve as a starting point for this calculation, which presents the basic steps for estimating the effects of public transit on a new development's parking demand.

$$\sum_{u=1}^{n} \sum_{t=1}^{24} S_{t,u} = \left(\frac{U \times K_t \times D_{t/u} \times W_t}{O_t} \right)(1 - M_t)$$

where:

S = Net reduction in parking demand when transit is provided during time period t.

t = One hour during a 24-hour day and weighted for 85 percent of demand during peak season.

u = Type of land use (e.g., office, industrial, retail, hospital, residential, amusement, etc.). Only necessary if development is mixed use or analysis covers more than one project (i.e., CBD, traffic analysis zone, etc.).

n = Number of different land use types to be included in the proposed development project.

U = Size of land use measured by units (e.g., square feet of floor space, number of employees, hospital beds, dwelling units, stadium seats, etc.).

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[6] Robert Weant and Herbert Levinson, *Parking*, 1990, p. 93.

K_t = Proportion of total trips to the site that occur during time period *t*.

$D_{t/u}$ = Person trips to the site per time period *t* per unit of land use *u*.

W_t = Proportion of workers or visitors for which the site is the primary destination during time period *t*.

M_t = Automobile mode share to the site during time period *t* when transit is available (i.e., percent of people coming to the site by car).

O_t = Average occupancy rate for automobiles during time period *t*.

The formula calculates peak parking demand over a 24-hour day. This demand, however, will fluctuate seasonally. Thus, the variables should be weighted for seasonal demand, especially the person trips to the site (variable "*D*"). The formula can be applied to a specific project or to all development within a zone, provided transit ridership (i.e., mode split) is more or less constant across the zone.

The mode share for autos when transit is available is the critical variable and should be estimated using reliable data and a travel demand forecasting model. When data for a new development are input into this formula, an analyst may plot a curve showing demand for parking spaces with and without transit. The difference between these two curves at the peak period of demand represents the net number for parking spaces that may be eliminated from a development because of trips diverted to transit. Figure 9.2 shows a hypothetical case, where the maximum net parking reduction is estimated at the morning peak hour of demand.

Each individual municipality must determine the specific reduction in parking requirements it believes is appropriate given the availability of transit.[7] The reduction depends on an individual project's proximity to transit stations and characteristics of their site design. The reduction may also be applied to an entire area as a special zoning condition. The City of Seattle, for example, has developed specific requirements for land use with high and moderate access to transit, as shown in Table 9.1.

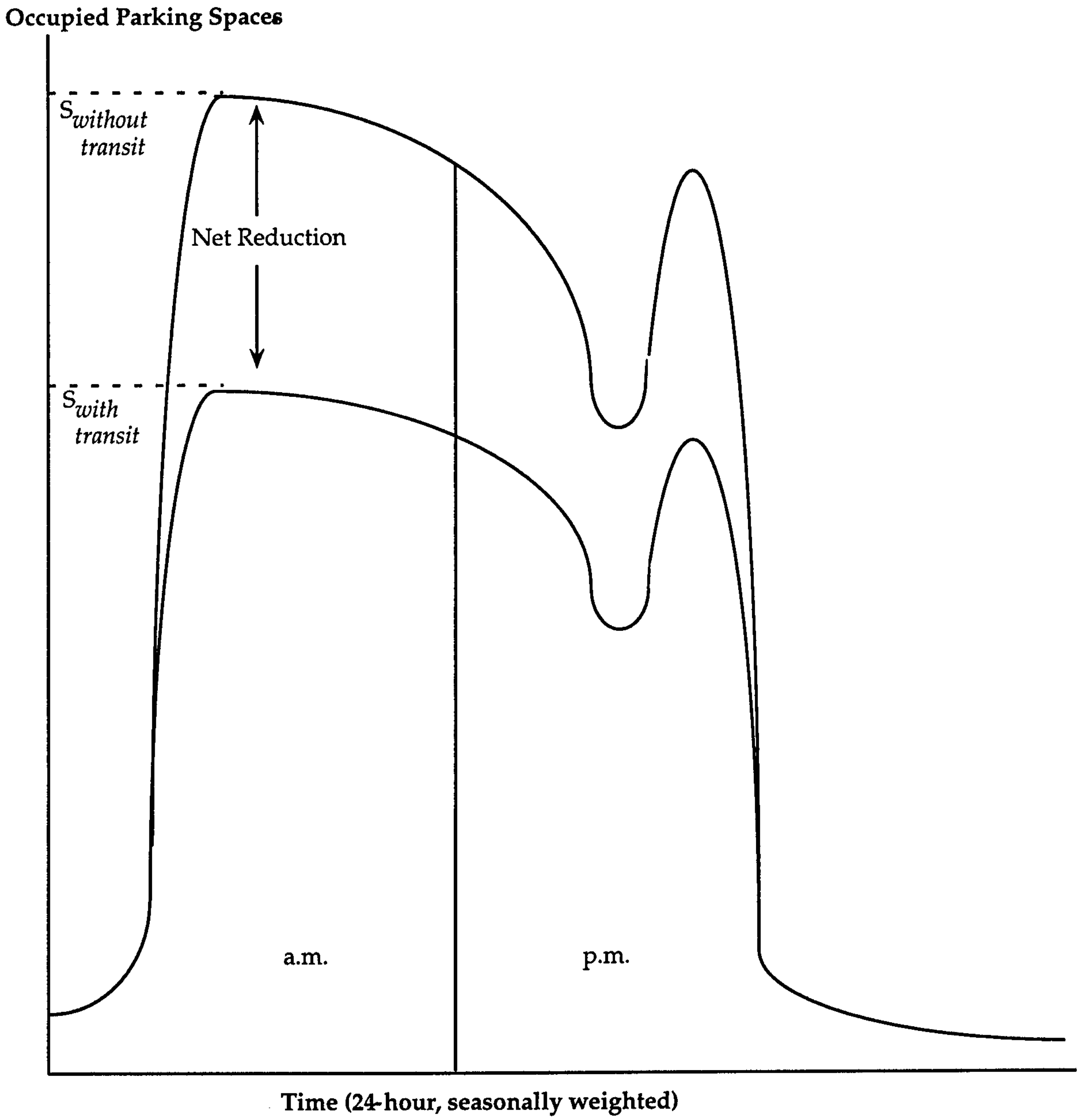
Table 9.1 shows that parking requirements for office development in high-transit-access areas are about 29 percent lower than the parking requirements for similar development in moderate-transit-access areas. For retail development, parking requirements in high-access areas are 52 percent of those in moderate-access areas.

The Boston Metropolitan Area provides another example of parking requirements indexed to transit accessibility. Over 20 years ago, the Massachusetts Department of Public Works in cooperation with the Federal Highway Administration (FHWA)

[7] In theory, the provision of public transit effectively lowers the minimum demand for parking by some number of spaces. As a practical matter, however, the minimum amount of parking demanded by tenants is difficult to pin down. Stochastic fluctuations in demand for parking may cause some tenants to value some margin of surplus parking more than others. The value of surplus parking increases when alternative parking is unavailable or expensive.

prepared minimum and maximum parking requirements based on distance from transit stops. These requirements, shown in Table 9.2, are illustrative guidelines that may be applied to major transit corridors.

Figure 9.2 A Hypothetical Estimate of Reduced Demand for Parking Over 24 Hours when Transit is Available



Currently, many transit investments are being made in urban areas that either have no transit service or have limited, relatively new systems that are being expanded. Many of these areas (e.g., Seattle, Phoenix, Denver, Orange County (California), Salt Lake City, etc.) have relatively lower densities of development or are only recently achieving high-density CBDs characteristic of older metropolitan centers with extensive fixed-guideway transit systems (e.g., New York, Chicago, Philadelphia, San Francisco, etc.).[8] The former have high parking requirements (and relatively plentiful supplies of parking),[9] reflecting heavy dependence on single occupant vehicle trips (i.e., an extremely low transit share). As a general characterization, these urban areas have evolved with auto dependent CBDs and must now retrofit transit systems into their cities.

Table 9.1 Parking Requirements for Downtown Seattle Expressed in Parking Spaces per 1,000 Gross Square Feet of Floor Area

	Office	Retail (except lodging)	Other Non-Residential	Lodging
Long-Term Requirements in Areas with High Transit Access				
Unrestricted Long-Term	0.54	0.32	0.16	1 space per 4 rooms
Carpool	0.13	0.08	0.04	1 space per 4 rooms
Total	**0.67**	**0.40**	**0.20**	**1 space per 4 rooms**
Long-Term Requirements in Areas with Moderate Transit Access				
Unrestricted Long-Term	0.75	0.56	0.16	1 space per 4 rooms
Carpool	0.19	0.14	0.04	1 space per 4 rooms
Total	**0.94**	**0.70**	**0.20**	**1 space per 4 rooms**
Short-Term Requirements in All Areas				
All Areas	0.1	0.5	none	none

Source: Robert Weant and Herbert Levinson, *Parking*, 1990, p. 48: Originally from the 1985 Seattle Parking Ordinance.

The high minimum parking requirements in these cities are often based on the common standard of four spaces per thousand square feet of leasable space, and an assumption that parking is provided free of charge or at a low fee. As a result, developers often provide the minimum number of spaces required by the zoning code. This minimum may be

[8] There are a significant number of exceptions to this assumption of sufficient or oversupply: South Boston, Los Angeles, Minneapolis/St. Paul, Portland (Oregon) are examples of areas with recent or proposed transit investments that have reasonably dense CBDs with parking supply at or below demand. Analysis of the benefits of reduced parking, therefore, must be tailored to the specific parking supply and demand characteristics of the area.

[9] An exception to this generalized situation is Portland, Oregon, which has experienced significant increase in CBD density. The city has capped CBD parking supply and invested heavily in transit. Thus, it represents an older CBD with a well established transit system.

Table 9.2 Boston Metropolitan Area Access Oriented Parking Strategy

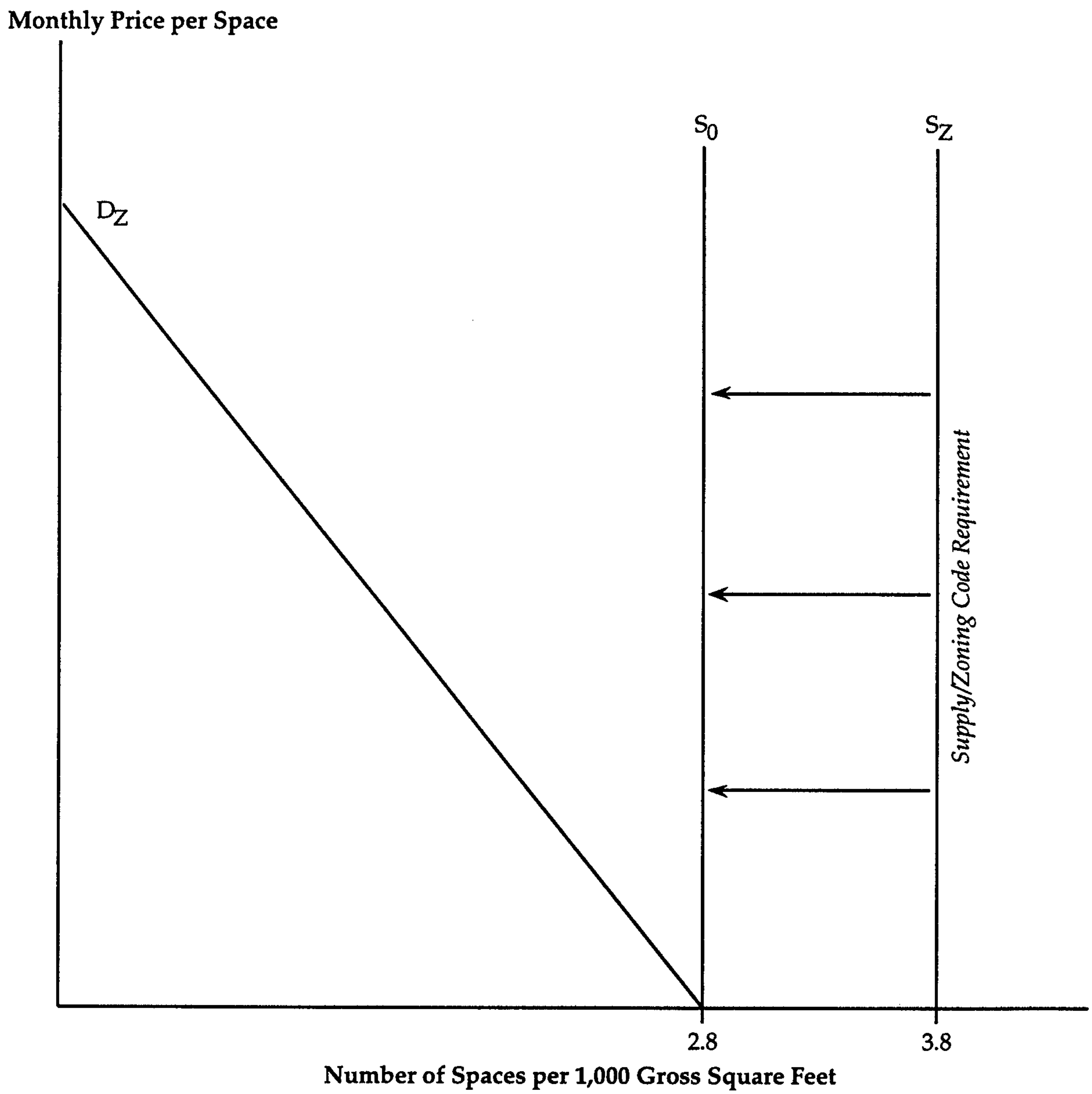
			Number of Spaces per Unit by Distance from Transit Stop					
			0 - 500 Feet		500 - 1,000 Feet		1,000 - 1,500 Feet	
Land Use	Activity	Criterion Unit	Minimum Required	Maximum Allowable	Minimum Required	Maximum Allowable	Minimum Required	Maximum Allowable
Residential	Single family	Housing unit	0.5	1.0	0.7	1.0	0.8	1.3
	Multi-family	Housing unit	0.4	1.0	0.6	1.0	0.8	1.3
Commercial	General Office	GFA, 1,000 sq. ft.	-	2.0	1.0	2.0	1.7	2.9
	Medical - Dental Office	GFA, 1,000 sq. ft.	-	3.3	1.7	3.3	2.5	4.0
	Retail	GFA, 1,000 sq. ft.	2.0	3.3	2.5	3.3	3.3	5.0
	Restaurant	Seats	-	0.17	0.17	0.25	0.17	0.25
	Hotel - Motel	Rental units	0.7	1.0	0.7	1.0	0.7	1.0
Industrial	Manufacturing, warehouse, wholesale	Employees	0.2	0.33	0.25	0.33	0.33	0.5
Institutional[a]	Auditorium	Seats	0.13	0.2	0.13	0.2	0.14	0.25
	Hospital	Beds	0.80	1.0	0.80	1.0	1.0	1.4
	Church	Seats	0.14	0.2	0.14	0.2	0.14	0.25
Educational	Elementary & junior high school	Classroom & office	0.7	1.0	0.8	1.0	0.8	1.0
	Senior high school	Classroom & office	0.7[b]	1.0[d]	0.8[b]	1.0[d]	0.8[c]	1.0[e]
	College & university	Classroom & office	0.7[b]	1.0[d]	0.8[b]	1.0[d]	0.8[c]	1.0[e]

[a] Where public use of an auditorium is likely, specific auditorium standards should apply.
[b] Plus 1 space per 10-15 students, except where constrained by policy.
[c] Plus 1 space per 8-10 students, except where constrained by policy.
[d] Plus 1 space per 8-10 students, except where constrained by policy.
[e] Plus 1 space per 5-8 students, except where constrained by policy.

Source: Estimated by Wilbur Smith and Associates for *An Access Oriented Parking Strategy for the Boston Metropolitan Area.* Final report prepared by Massachusetts Department of Public Works in cooperation with Federal Highway Administration (July 1974). Table appears on page 49 in Weant and Levinson, *Parking*, 1990, page 49.

modeled as a vertical supply curve (S_Z) shown in Figure 9.3.[10] The downward sloping demand curve, D_Z, shows that as the price of parking decreases, workers (and visitors)

Figure 9.3 Parking Demand and Supply in Suburban and Auto Dependent Urban Areas



Source: Cambridge Systematics, Inc.

[10] A vertical supply curve is also consistent with a fixed short-term supply of parking, which is usually the case given a finite supply of land suitable for parking and the relative long lead time necessary for construction of new parking, especially structured or underground parking. The inelastic short-term supply contrasts with the high variability in short-term demand, which can fluctuate daily.

will use more parking. The adequate supply or oversupply of parking, however, means that the demand for parking either (D_Z) intersects the supply curve (S_Z) at the x-axis or it never intersects the supply curve. The market, therefore, will not indicate the most efficient quantity of parking at any price.

These requirements are often based on the common standard of four spaces per thousand square feet and assume parking is provided free of charge or at a low rate. As a result, developers often provide the minimum number of spaces required by the zoning code.[11] Thus, the minimum parking requirements may be modeled as a vertical supply curve (S_Z) shown in Figure 9.3. The downward sloping demand curve, D_Z, shows that as the price of parking decreases, workers (and visitors) will use more parking. The adequate or oversupply of parking, however, means that the demand for parking either never (D_Z) intersects the supply curve (S_Z) at the x-axis or it never intersects the supply curve; therefore, the market will not indicate the most efficient quantity of parking at any price.

Parking utilization surveys often show actual peak-demand levels between 2.0 and 3.0 spaces per 1,000 gsf.[12] Utilization rates for five Southern California case studies, for example, report parking occupancy at large suburban office parks averaged 56 percent of capacity at peak periods.[13] Furthermore, the Institute of Traffic Engineers reports average parking generation rates of 2.8 spaces per 1,000 gsf for general office buildings and 2.5 spaces per 1,000 gsf for business parks, assuming parking has zero cost to the driver. Thus, the supply curve (S_Z) may be shifted left to where it intersects the x-axis at 2.8 space (S_0). If parking requirements for new development are similarly changed, two important impacts will occur. First, developers will save on costs of constructing parking, including the cost of land. Second, because less land must be devoted to parking, developers will be able to provide more built space within the same lot dimensions. (This latter benefit is only possible when demand is strong enough to absorb the additional supply.)

In Figure 9.4, parking requirements (Q_Z) are lower than demand. Under one scenario, a developer might provide more than the minimum required parking (Q_D) and can charge a price (P_D) for parking. This situation would be most likely to occur in higher density urban areas and CBDs where the supply of parking is constrained. In this case, land costs would be high and developers would likely build expensive structured or underground parking in order to maximize leasable space on a finite amount of land. The supply curve (S_Z) is slightly sloped and developers can collect a parking charge (P_D).

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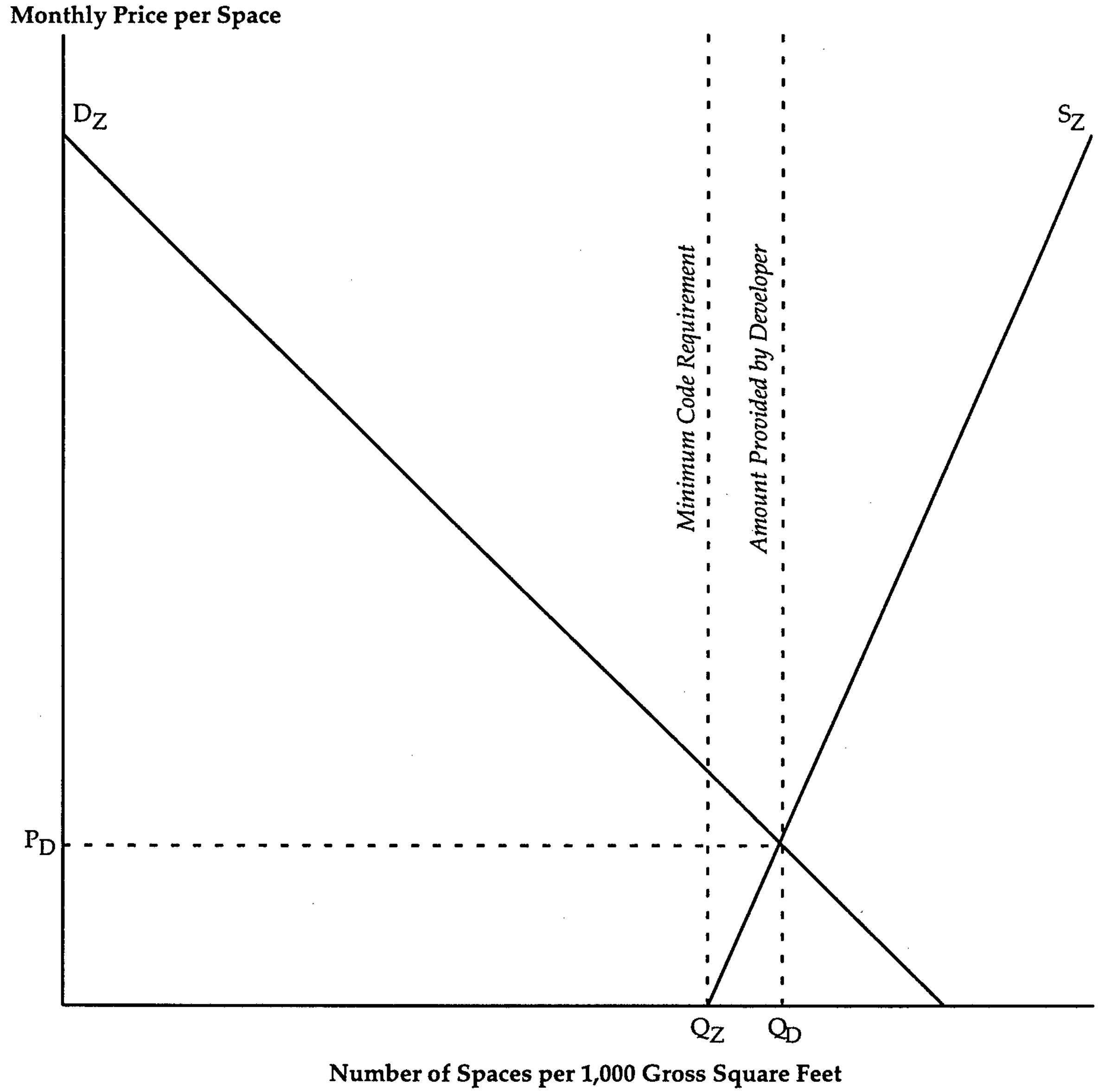
[11] Richard Willson, "Suburban Parking Requirements," *Journal of the American Planning Association*, Vol. 61, No. 1, Winter 1995, p. 34.

[12] Smith and Hekimian, 1985; Gruen Gruen & Associates, 1986; Institute of Transportation Engineers, 1987; Cervero, 1989. A utilization survey of Seattle suburbs reported an average surplus of 36 percent more spaces (Municipality of Metropolitan Seattle, 1991).

[13] This average utilization rate was for five "typical" suburban sites in Southern California (Willson, 1995).

Figure 9.4 Parking Demand with a Constrained Supply of Parking



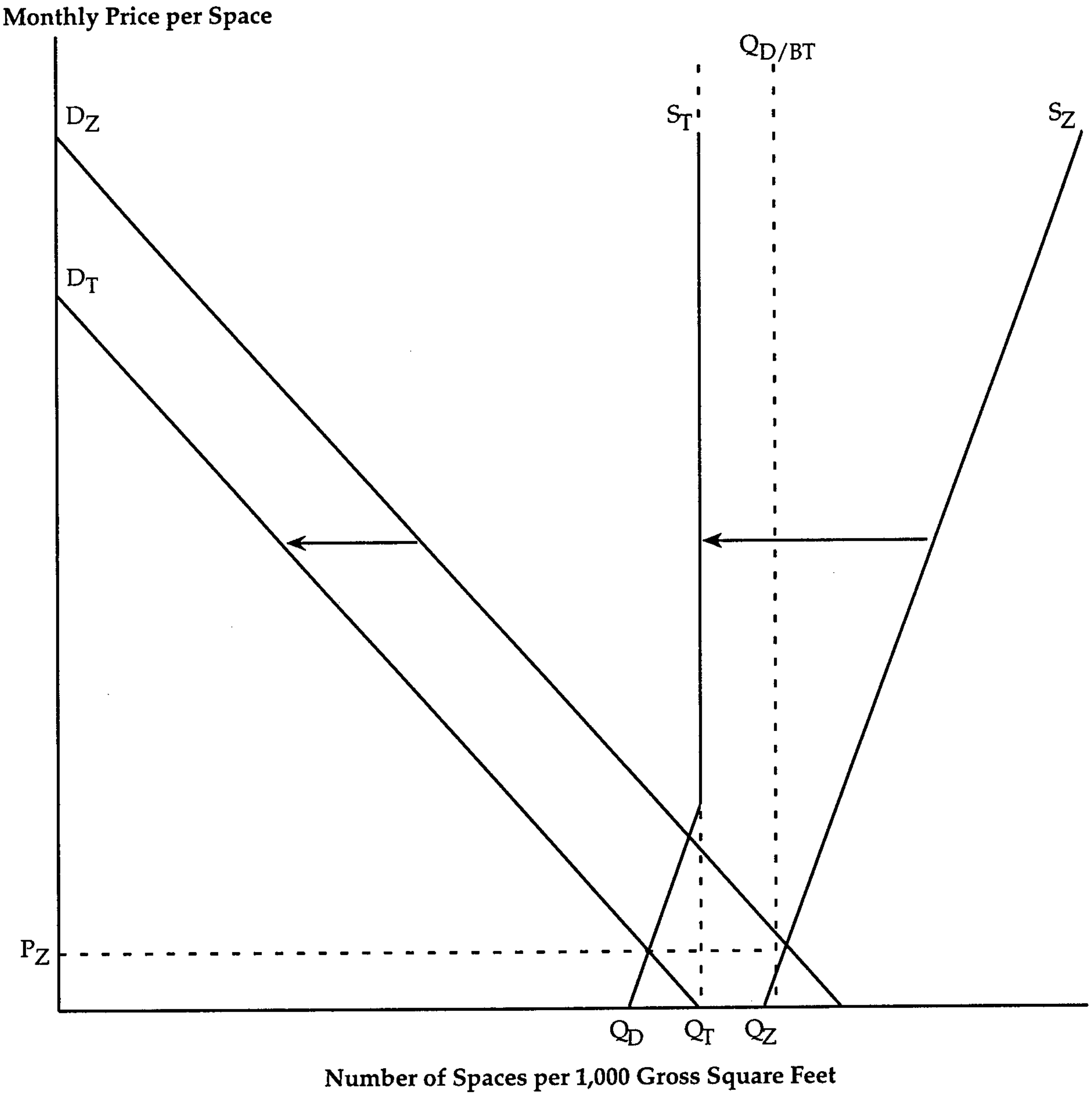
Source: Cambridge Systematics, Inc.

Figure 9.5 shows what happens when transit service is introduced. Demand for parking decreases from D_Z to D_T. In this case, the minimum amount of required parking before transit (Q_Z) is lowered (to Q_T) by imposing a maximum amount of required parking (S_T).[14] This maximum is set at an amount proportional to the mode shift with transit. Thus, in

[14] Alternatively, a reduction in the parking requirement could be accomplished by lowering the minimum requirement. In this case, the supply curve would be upward sloping along its entire length and parallel to S_Z.

the short-term, the downward-sloping supply curve (S_Z) shifts left to a vertical supply curve (S_T). Since the parking requirement is a maximum, the supply curve begins to slope at the intersection of new demand curve for parking with transit (D_T). The actual decrease in supply is from the quantity provided by developers before transit (slightly more than the minimum requirement, $D_{D/BT}$) to Q_T.

Figure 9.5 Parking Demand and Supply with the Introduction of Transit



In this hypothetical example, the price that developers can charge for parking remains at the pre-transit level (P_Z). Thus the entire benefit of reduced parking requirements is captured in the developers' savings in the foregone construction costs of parking and the opportunity costs of the additional leasable space that may be substituted for parking. If drivers did not switch to transit at the rate anticipated, prices would rise. If no drivers shift to transit, the price would rise to where the pre-transit demand curve (D_Z) intersects the after-transit supply curve (S_T).

Market Forces and the Allocation of Benefits

The beneficiary of lower parking requirements is determined by the markets for land and building space. While these two markets are closely linked, their relative scarcity, the knowledge of participants in the development process, and a host of other market forces will determine whether the land owner, the developer, or the tenant realizes some or all of the benefits. While an analyst may be relatively certain that reduced parking generates real benefits, who actually benefits from reduced parking requirements is difficult to determine, especially in the long term. This discussion is intended to summarize the major forces affecting who will enjoy the benefits of reduced parking.

- **Land owners** who know the value of the benefits to the developer capture the majority of benefit when raw land or underutilized sites that could be developed or redeveloped are scarce and low vacancy rates are encouraging developers to build more space. A shortage of land in a high-demand area drives the price of land up, thus increasing the market leverage of land owners holding the few available parcels. They may sell their land at a premium. In this case, the benefit of the reduced parking is high and the benefit tends to accrue to land owners. When the demand for land is weaker, the cost of the land is lower and parking itself becomes less costly for a developer to provide. In this case, the benefit of a reduced parking requirement tends to be less and it does not accrue to the land owner.

- **Developers** may garner most or all of the benefit if they know the value of the benefits. In addition, vacancy rates must be low (i.e., the supply of competitive building space must be scarce and tenants abundant), and sufficient land available to weaken the leverage of land owners. Under these conditions, developers may substitute leasable space for parking, and tenants (who are competing for scarce space) are more likely to forego cheaper, more abundant parking.

- **Tenants** may accrue the value of the benefits over the life of their lease if they know the value of the reduced parking benefit and vacancy rates are high. Under such circumstances, their gain may come at the expense of the developer or the land owner or both, depending on the other market conditions. High vacancy rates, for example, would force developers to lower lease rates, thus passing the benefits of reduced parking on to the tenant. The leverage of tenants, however, may be somewhat diminished by the attractiveness of building space with good access to transit.

Figure 9.6 shows a matrix of market forces affecting who in the development process accrues the benefits from reduced parking requirements. The table is general and does not provide an analyst with a template for a specific situation. Furthermore, it assigns benefits over one development cycle (i.e., from the beginning of one building boom to the beginning of the next). Many of these assignments will shift over the mid-term or long term.

Figure 9.6 Allocation of Benefits of Reduced Parking Requirements

	Benefits of Reduced Parking to:		
Market Conditions	**Land Owner**	**Developer**	**Tenant**
Available land/high vacancy	**no benefit**	**modest benefit –** reduced land cost[1]	**large benefit –** lower lease cost
Available land/low vacancy	**no benefit**	**large benefit –** reduced land cost and high lease	**no benefit**
Scarce land/high vacancy	**moderate benefit –** higher land prices	**no benefit**	**moderate benefit –** lower lease cost
Scarce land/low vacancy	**large benefit –** higher land prices	**large benefit –** higher lease cost and more leasable space[2]	**no benefit**[3]

Notes:

1 Given high vacancy rates, developers would not be building significant amounts of space except as long term investments that will most likely encounter different market conditions. Thus, modest benefits only accrue to developers with projects underway.

2 Assumes that the increase in leasable space due to substitution for parking does not significantly increase vacancy rates.

3 The substitution of leasable space for parking would only partially offset the low vacancy rate. On the margin, therefore, the benefits of reduced parking may accrue to the tenants of the additional space. In the long term, low vacancy rates would stimulate developers to building more space.

Source: Cambridge Systematics, Inc.

In a strong market (i.e., low vacancy), high demand for scarce building space would absorb all the square feet of space a developer could provide on a constrained supply of land. Thus, lower parking requirements would allow a developer to substitute leasable space for parking stalls. The benefit of a strong market is that the developer gains the marginal profit generated by the additional leasable space that would have been otherwise devoted to parking. In a strong real estate market, this foregone profit may be a substantial part of the benefit derived from the parking reduction.

An important exception to this scenario could occur where zoning restrictions limit the density in urban land markets. A maximum density zoning requirement could constrain a developer from substituting leasable space for parking. Under such circumstances, higher levels of parking may be profitable. Thus, a reduced parking requirement (imposed as a *maximum* number of allowed spaces) could set supply of parking stalls below market demand, imposing a cost rather than a benefit on a developer equal to the foregone profit on the disallowed spaces.

The residual benefit in a strong market depends on the profitability of the parking stalls in their own right. If the developer can charge parking rates that exceed the cost of the stalls' construction and maintenance/operation, then this profit must be subtracted from the profit of substitute leasable space. If parking stalls cost more to construct and maintain/operate than can be generated from their use, this foregone cost may be added to the marginal profits generated by substitution of leasable space for parking.

In a weaker market, a reduced parking requirement could lower development costs sufficiently to allow projects to proceed that would not otherwise have generated an adequate return to the developer. This improvement to a project's feasibility may come about in the following ways.

1. The cost savings due to reduced parking requirements may be applied to other project costs, allowing a project to move forward.

2. The space previously needed to provide parking may be used for (and the cost savings may be used to finance) additional amenities to enhance the marketability of the project. These amenities would attract more affluent tenants or accelerate absorption, thus increasing lease revenues to the developer or justify building more space on the land previously used for parking.

3. The cost savings may be used to lower rent or provide other concessions that would make the property more competitive.

The Cost and Price of Parking

The true cost of providing parking depends on the type of parking (i.e., surface, structured, or underground), the cost of land and construction, and the real estate market. This latter category may be the most critical. The real estate market determines the "opportunity cost" of using land for parking. Opportunity cost is measured as the value of the land used for parking if instead it could have been put to a higher and more profitable use. The opportunity cost of reduced parking may constitute the majority of the benefits in a strong real estate market.

Cost of Parking

The cost of parking may be broken into four components: land, construction, financing, and operations/maintenance. The per unit cost of each component – especially the first two – varies widely among regions and even adjacent parcels; thus, an analyst interested in the benefits from reduced parking must collect accurate cost data for each component. The following are break-even cost estimates needed to cover construction, operations, and maintenance. The cost estimates assume a land value of $11 per square foot, 370 square feet per space, and $1,000 per space construction costs with all capital costs amortized at 7.5 percent over 30 years and monthly operating costs of $1.60 per space (all costs in 1992 dollars). The costs below are provided as rough comparisons among the component costs:

- **Surface lot stalls** cost roughly $2,000 to build, not including the cost of land. As a very rough benchmark, the amortized cost of surface parking is $37 per month (including $29 per month for land). In a case study of suburban office developments in Southern California, monthly parking costs for six surface lots were on average $48 per space with a range between $28 and $61, depending on the land costs and the efficiency of the lot's design.[15]

- **Multilevel structure stalls** cost roughly $5,000 to build, not including the cost of land. For structured parking, the amortized monthly costs averages $97 per space. The construction costs for the structure range between $9,000 and $12,000 per space.[16]

- **Underground stall** costs range roughly between $20,000 and $24,000 to build, depending on the seismic design requirements and subsurface soil conditions.[17]

Parking stalls – whether surface, structured, or underground – require roughly 400 square feet, including space for aisles and driveways. Two very general rules of thumb are that a developer 1) needs about one and one-half times as much space for parking as is needed for people using the leasable space[18] and 2) will construct structured parking instead of surface parking at a floor-area-ratio (FAR) over 0.4.[19] The choice between underground and multilevel structured parking is more complex and often dictated by the zoning code, subsurface soil conditions, and financing constraints.

Table 9.3 provides a set of aggregate cost categories for each of the three types of parking: surface, multilevel stand-alone structure, and underground (with building space above). The costs shown in Table 9.3 are generic and based on a set of assumptions constant across all three types of parking. Although the high and low figures represent national averages, actual values depend on a particular project. In dense urban areas with limited vacant land, for example, land costs may be far in excess of these average costs. The total break-even costs shown as the bottom line of the table represent an approximate range of costs that a developer can avoid by not building a parking stall. These numbers, however, do not represent a net savings. To calculate a net benefit, parking revenues (if any) must be subtracted from the break-even cost and compared to the net earnings on leasable space that may be substituted in place of the parking (if any).

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[15] These costs, however, are based on full occupancy of all spaces. Given that national occupancy rates for parking average 50 percent of capacity, the cost of a parking stall increases from $37 per month to roughly $74 per month. The Southern California case studies calculated an increase from $48 per space per month to $92 for suburban surface lots. (Richard Willson, "Suburban Parking Requirements," *Journal of the American Planning Association*, Vol. 61, No. 1, Winter 1995, p. 31).

[16] Assuming a 50 percent occupancy rate, the cost of a parking stall increases from $97 per space per month to $161 for structured parking. (Richard Willson, "Suburban Parking Requirements," *Journal of the American Planning Association*, Vol. 61, No. 1, Winter 1995, p. 33).

[17] Shoup, Donald. "The True Cost of Free Parking," *Parking Today*, August 1997.

[18] This need should not be confused with parking requirements, which average roughly around four spaces per 1,000 square feet of office space and one space per 350 square feet of retail development.

[19] A 0.4 FAR is equivalent to a 40,000-square-foot building on a 100,000-square-foot lot. (Joel Garreau, *Edge City*, Doubleday, 1991, pp. 118-121).

Table 9.3 Cost Estimates Per Parking Stall (1997 Dollars)

	Surface Lot		Above Ground Multi-Level Structure		Below Ground	
	low	**high**	**low**	**high**	**low**	**high**
Land	$600	$12,000	$500	$1,000	$0	$0
Construction	1,500	4,000	8,800	20,000	16,000	40,000
Design, Engineering, & Contingency	200	800	1,800	5,000	3,200	10,000
Project Costs	**$2,300**	**$16,800**	**$12,100**	**$26,000**	**$19,200**	**$50,000**
Present Value of Annual Interest Payments	2,100	14,700	9,700	22,700	16,800	43,700
Present Value of Annual Operating Costs	700	2,800	2,800	5,600	2,800	5,600
Total Break Even Cost per Parking Stalls	**$5,100**	**$34,300**	**$24,600**	**$53,300**	**$38,800**	**$99,300**

Assumptions:

1. **Land costs** range between $600 to $12,000 per stall for surface lots; between $500 to $1,000 per stall for multilevel structures (average for three or more levels); and zero cost for underground parking.
2. **Construction costs** range between $5 to $10 per square foot for surface lots; between $28 to $50 per stall for multilevel structures; and $50 to $100 per stall for underground parking.
3. **Design, engineering, and contingency costs** range between 15 to 20 percent for surface lots and between 20 to 25 percent for multilevel structures and underground parking.
4. **Interest expense** is the present value for a 24-year loan at 9.0 percent discount rate.
5. **Operating cost** is the present value (discounted at 9.0 percent) over 24 years for monthly costs of $0.25 to $1.00 per stall for surface lots and between $1.00 to $2.00 per square foot for multilevel structures and underground parking. These include utilities, attendant, insurance, overhead, janitorial service, routine repairs, etc.

Sources *Parking*, Robert Weant and Herbert Levinson and Cambridge Systematics, Inc.

An estimate of the monetary benefits that result from reduced parking for a specific project requires a detailed pro forma analysis. Pro forma analysis is a standard financial planning tool in real estate development. It presents project costs and revenues over time and calculates a net profit (or loss) in each year (or month). In order to estimate the benefits of reducing parking at developments in close proximity to transit service, the analyst must prepare two pro forma analyses: 1) one that assumes no transit service and no reduction in required parking; and 2) one that assumes transit service is available and parking requirements are reduced. The net difference between the second and the first represents the benefits.

Figures 9.7 and 9.8 provide generic operating and investment templates itemizing parking costs and revenues that should be included in a general pro forma analysis. An actual pro forma may include line items specific to the type of development (e.g., office, amusement, industrial, big-box retail, etc.). Specific values depend on the particular project and have not been included here.

Ideally, these templates should be set up to analyze a parking facility as an integral part of a development's primary land uses, such as an office tower, retail mall, etc. Such a comprehensive pro forma analysis is a complex undertaking and requires access to confidential information that most developers would not be willing to make available to outside parties. An analyst, therefore, should expect to prepare a pro forma for the parking facility as a stand alone project.

This approach simplifies the analysis, but it ignores the very important financial consequences that would occur when leasable space is substituted for the reduced parking. Under this circumstance, it is important to estimate the profit a developer would earn on each increment of leasable space he or she can substitute for each increment of reduced parking. The necessary information may be obtained from interviews with the developer, asking real estate experts to make estimates, or examining the project proposal and approval documents on record at the local planning department.

To estimate the net annual benefits of reduced parking, an analyst would prepare two versions of an operating pro forma sheet modeled after Figure 9.7. The net annual savings would be the difference in Spendable Income (line 7) between the two pro formas. Taking the net present value (NPV) of the income stream provides a single cost that may be added to the investment savings calculated in the investment pro forma (Figure 9.8).

A second investment pro forma analysis must be completed for the construction period of the project (Figure 9.8). The investment pro forma itemizes all the capital costs of construction. It can usually be collapsed into a single column of costs unless construction is phased over a long period of time (i.e., five or more years). For a phased project, an analyst should determine if lower costs due to reduced parking occur evenly throughout the construction period or are grouped together during a specific phase.

To estimate the net one-time capital benefits of reduced parking, an analyst would prepare two versions of an investment pro forma sheet modeled after Figure 9.8. The net benefit would be the difference between the Total Investment (line 10) of the two pro formas. The total net benefits of reduced parking equal the NPV of the stream of operating savings (from Figure 9.7) and the NPV investment difference.

Figure 9.7 Generic Operating Pro Forma Analysis Template for Paid Parking Facilities

Operating Pro forma	1998	1999	2000	etc.
Gross Income Annual rent (#stalls x rate/day x 365 or 260, depending on land use[1]) Other income				
1. Total Gross Income				
Vacancy & Collection Loss Allowance (vacancy rate x annual rent) plus collection losses, etc.				
2. Total Vacancy/Collection Loss **3. Effective Gross Income** (#1 – #2)				
Operating Expense Property Management (payroll, legal, accounting, marketing, brokers, advertising) Utilities, Energy, Communications Repairs, Maintenance Contingency (to carry one year of operating costs and two months of financing costs)				
4. Total Operating Expense **5. Net Operating Income** (#3 – #4)				
Fixed Costs Property & Title Insurance Mortgage Interest/Debt Service Real Estate Taxes Replacement Reserve				
6. Total Fixed Costs				
7. Spendable Income (#5 – #6)				
8. Capitalization Rate (#5 ÷ #10)				
9. Cash on Cash (#7 ÷ Equity)				

1 If a parking facility is used primarily during the work week (e.g., by employees of office buildings), 260 should be used, as there are approximately 260 work days in a year. If the parking facility is used seven days a week at full capacity (e.g., parking for a major retail development), it may be appropriate to use 365 days.

Source: Cambridge Systematics, Inc.

Figure 9.8 Generic Investment Pro Forma Analysis Template for Paid Parking Facilities

Total Investment	Construction Period[1]			
Hard Costs (includes parking)				
Land Cost				
Site Development (site preparation, earthwork, paving/ roads/parking, drainage, sewer, water, electricity/ phone, landscaping, site amenities)				
Parking Construction				
Signage, Revenue Control and Security Equipment				
Other Hard Costs				
Contingency				
10a. Total Hard Costs				
Soft Costs				
Architect Fee				
Other Fees (structural, mechanical, civil, landscape, etc.)				
Legal/Accounting				
Developer's Overhead & Fee				
Builder's Insurance				
Permits, Licenses				
Construction Loan Interest/Debt Service				
Financing Fees/Points				
Other Soft Costs				
Contingency				
10b. Total Soft Costs				
10. Total Investment (10a + 10b)				

Notes:

1 Construction may last only one year or be phased, extending over a number of years.

Source: Cambridge Systematics, Inc.

Price of Parking

In a free or unregulated market, developers would provide the quantity of parking and charge a price that would maximize their profits.[20] Although determining this optimal supply and price involves a complex balance between many factors, it is basically a three-way tradeoff between: the willingness of tenants to lease the available space with a

[20] In a minority of cases when parking generates a profit, alternative uses are in some way regulated that leaves parking as the highest and best use of the available land. Parking on the abandoned piers along the San Francisco waterfront, for example, has been profitable to the Port of San Francisco because all other profitable uses are excluded by local and state laws.

minimum supply of parking, the cost of constructing parking, and the highest price that can be charged and still obtain full (or near full) occupancy.

In almost any situation where transit service is being proposed or exists, however, the supply of parking is almost always regulated. Thus, developers set the price of the parking such that they can recover some, all, or even more than the capital and/or operating cost of parking through some mix of the three following approaches:

- **Free Parking.** Parking is provided at no charge to the driver and the funding for its construction and operation are incorporated into the price of the lease for space. Depending on the strength of the real estate market and the availability of competitive space with sufficient "free" parking, a developer may recover the full cost of parking from the lease revenues. This approach usually involves lower-density development on low-cost land.

- **Break-Even Charges.** Parking rates (hourly, daily, or monthly) are set such that the capital and operating expenses of the facility are fully funded from the facility's revenue stream. This approach may be used also to supplement the revenue stream from an assessment district formed to repay the debt on a public parking structure.

- **Profit Maximizing Charges.** In areas of sufficiently strong demand or where parking is one of a few land uses allowed under the zoning regulations, paid parking can generate a profit. Some underground parking in high-density urban development, for example, offers such opportunities. Parking rates are set as high as the market will bear.

The average price of paid parking in North America ranges from less than a dollar per day in rural areas to over $8 per day in urban areas with over 3,000,000 population. Figure 9.9 summarizes these findings.[21]

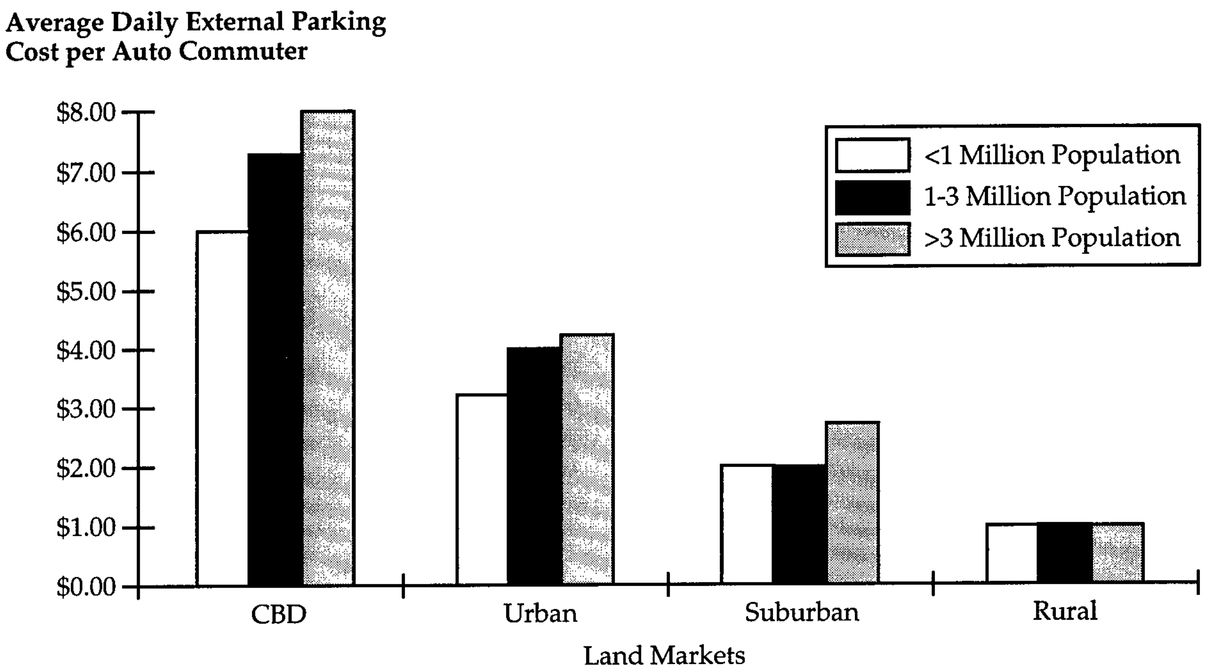
The amount a developer charges and the method he or she uses has a direct effect on the net benefits derived from reduced parking requirements. "Free" parking provides no incentive for drivers to use transit. Thus, the mode shift to transit for areas with free parking will be low compared to areas with only paid parking, and as the charge for parking increases, mode shift to transit should increase. The influence of parking prices and access to transit on mode shift, however, depends also on congestion, car ownership, travel demand management (TDM) incentives, and other non-price factors. A possible unintended side effect of increased parking prices, particularly for retail development, is that competing destinations with free parking available may become more popular.

Increased parking revenues allow a developer to cover more of the cost of providing parking, and in some cases to generate a profit solely from the parking revenues. Under these conditions, the benefits to a developer of reduced parking requirements diminish as the gap between revenue and cost narrows. Reduced parking requirements

[21] Don Pickrell, "Eliminating Employer-Subsidized Parking," in *Climate Change Mitigation: Transportation Options*. Volpe National Transportation Systems Center (Cambridge) for U.S. Environmental Protection Agency, 1993.

(implemented as a maximum allowable parking requirement) become a disbenefit to the developer at the price point at which that parking becomes profitable, if he or she cannot substitute a higher and better use for the parking. Nevertheless, the public will still benefit because higher parking prices or reduced parking supply will increase transit ridership, thus increasing farebox recovery, reducing congestion, improving air quality, etc.

Figure 9.9 Average External Parking Costs per Automobile Commuter



Source: Don Pickrell, "Eliminating Employer-Subsidized Parking," in *Climate Change Mitigation: Transportation Options.* Volpe National Transportation Systems Center (Cambridge) for U.S. Environmental Protection Agency, 1993.

Second-Order Impacts

The benefits described above accrue directly to the land owner, developer, or tenant; they are monetary and relatively short-term. In addition, second order impacts (both benefits and disbenefits) occur when parking requirements are reduced. These impacts are usually longer-term and more difficult to convert into monetary values. They also tend to accrue to the public at large. The following six impacts are examples of additional benefits and disbenefits conferred on the general public. For the most part, they are not quantifiable.

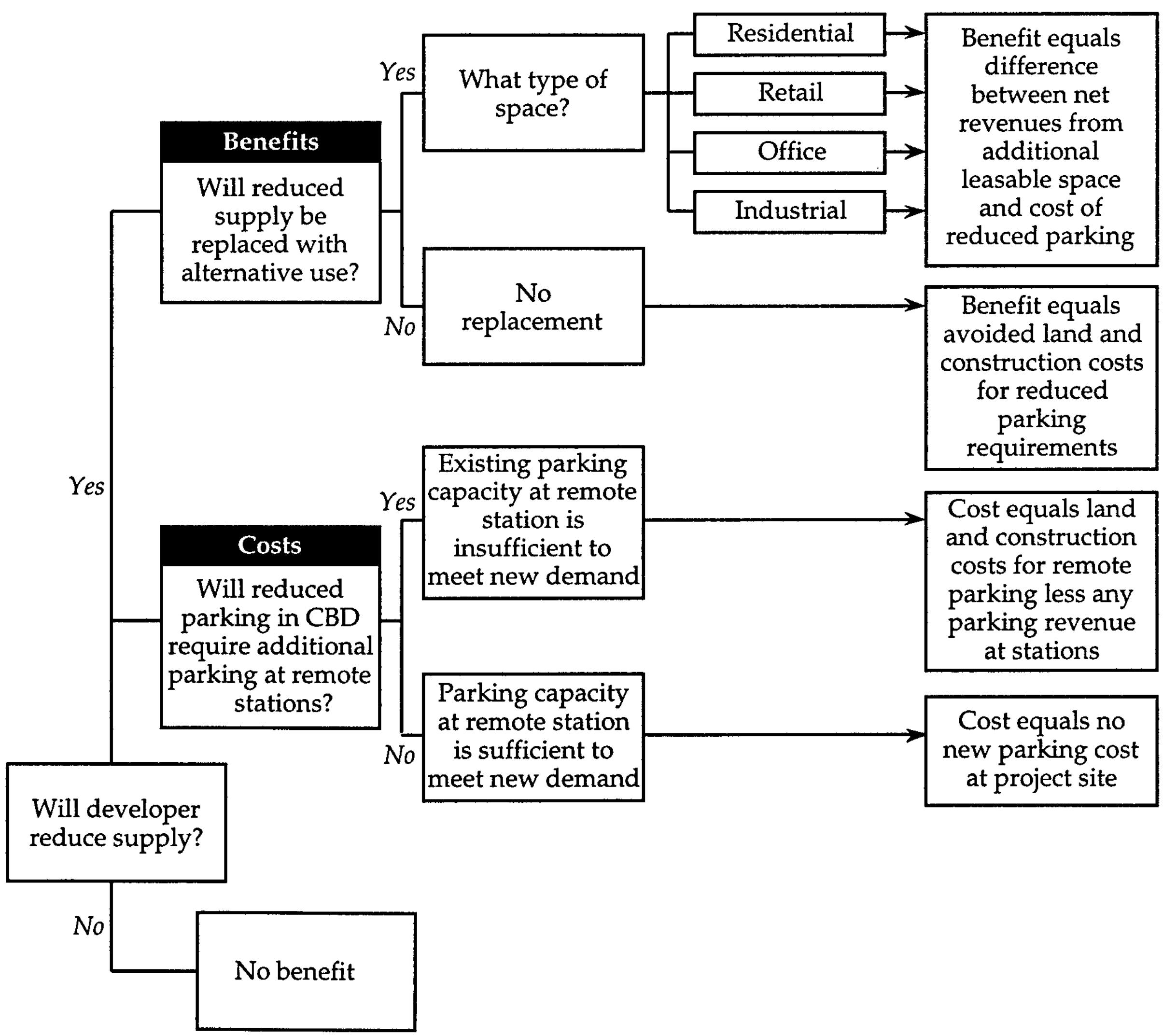
Parking Demand at Suburban Transit Stations

Most transit home-to-work trips to urban employment centers involve an automobile driver parking at a suburban transit station and then riding transit to work. These stations provide parking (sometimes free) for riders that drive their cars from their homes. When parking requirements are reduced at the work place (i.e., the CBD), the reduction is in *response* to the availability of transit and thus intended to reduce the supply of parking in the CBD.

Some transit systems, however, have extremely constrained supplies of parking at their suburban stations (e.g., BART in the San Francisco Bay Area). For these systems, a reduction in parking requirements for development near existing or new urban/CBD transit stations as service is extended (i.e., the job end of a trip) increases the demand for parking at the suburban transit station. As a result, the actual benefit of reduced parking requirements should be decreased by the cost of providing parking at the suburban transit station (home-end of commute trip).

Figure 9.10 shows the decision path an analyst should follow to determine the type of benefit a parking reduction may generate.

Figure 9.10 Net Benefits of Reduced Parking for Urban, Transit-Served Areas



Parking at suburban stations is generally less expensive than in urban employment locations because of lower land costs and the increased likelihood that surface lots can be built rather than structured or underground parking. The net benefit, therefore, still should be positive. Furthermore, not all new riders will require parking at the suburban station if feeder buses, carpools, and other alternative modes are available for the trip from home to a transit station.

Episodic or Unexpected Demand

Reducing parking requirements will force a developer to gamble that future events will not create frequent episodes of peak parking demand in excess of the available supply. As a general rule, parking supply is sized to accommodate 85 percent of the highest daily peak demand in a year. Thus, developers are already balancing adequate parking supply with cost-cutting design considerations, and the further reduction in parking due to transit service should not affect the demand for parking more on peak days than off-peak days. Nevertheless, a number of scenarios could generate more parking demand from transit riders. These scenarios include:

- Temporary or long-term transit service outages due to natural disasters (e.g., earthquakes, floods, power outages, etc.), strikes, maintenance problems, etc.
- General decline in transit service quality including reliability, safety, fewer operating hours, route restructuring, increased fares, and equipment attrition.
- Special events such as conventions (out-of-town visitors), sidewalk sales, concerts, etc., that encourage or require that people use their cars.
- Change in building tenants from one with more transit-oriented workers or clientele to one that is more auto-oriented.

The costs that these scenarios impose on a tenant or owner may be temporary or longer-term. Consequences include illegal street parking, lost store or office patronage, higher vacancy rates, lower rental income, etc. In addition, excess parking demand frequently results in spill-over to on-street spaces, thus increasing traffic congestion, displacing shoppers, and disrupting neighborhoods. Given limited experience with these occurrences, they are difficult to quantify.

Increased Farebox Revenue

When transit is available as an alternative mode, a jurisdiction may reduce parking requirements by two increments. The first reduction is an amount equal to the voluntary mode shift. This assumes parking remains at the same general price level after transit is introduced. This first reduction is in response to drivers who decide to ride transit; thus, the minimum parking requirements are reduced as an acknowledgment that those requirements are too high given transit's mode share. This reduction, therefore, does not *cause* an increase in farebox revenues.

A second reduction in parking requirements (i.e., a parking maximum requirement) could induce more drivers to ride transit by making parking scarce. This scarcity means drivers must either wait for spaces to become available, walk to their final destination from remote parking lots, or pay more for the remaining spaces (or pay for previously free parking). Regardless of which option is available, this second reduction will cause more drivers to use transit (and some other alternative modes as well). Their ridership will increase farebox revenues and farebox recovery rates; thus fares are not increased (or not increased as much).[22]

Land Conservation

This section identifies three types of land conservation that may result from reduced requirements for parking:

1. The creation (or conservation) of urban open space that would have otherwise been used for parking;

2. The conservation of suburban open space because suburban development is shifted to the urban or CBD areas; and

3. The lower consumption of suburban land for parking at suburban developments.

The first two cases involve more typical transit investments. The first case is a straight substitution of urban open space for parking. The open space may be required by the zoning code, but many developers are finding this amenity adds to the marketability of their property. In the second case, transit into the CBD improves access and reduces the need for developers to construct expensive structured or underground parking. Thus, development in urban areas or the CBD becomes more feasible and may attract development that would otherwise occur on suburban open space.

The last example involves less traditional transit systems that have been constructed in (or are being planned for) more suburban or low-density urban areas.[23] For most suburban office parks and retail malls, surface parking and stand-alone structured parking take up significant amounts of land. This is especially true for campus-style suburban office parks, which are generally surrounded by acres of surface parking at a rate of roughly four spaces per 1,000 square feet of building or approximately one and one-half times as much space for cars as people.[24] A developer who is required to build less surface parking, therefore, will purchase less land than he might otherwise have been required. The smaller purchase lessens the competition for raw land and hence exerts less upward

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[22] It must be acknowledged that this benefit would result in a reduction in the Highway Trust Fund revenues, but at the local level this loss would be insignificant.

[23] Examples include the light rail systems in Santa Clara County (i.e., Silicone Valley) and Sacramento, California, and planned systems in Salt Lake City and the western and southern extensions in Portland, Oregon.

[24] Richard Willson, "Suburban Parking Requirements," *Journal of the American Planning Association*, Vol. 61, No. 1, Winter 1995, pp. 30 and Joel Garreau, *Edge City*, Doubleday, 1991, pp. 118.

price pressure. A local government may then purchase the land for the lower price and preserve it as public open space. The savings accrue to local taxpayers, who would otherwise have to spend more for the same amount of land or who would have bought less land for the same amount of money. The price differential between the cost of acquiring land for public open space with and without the parking reduction provides a monetary estimate of the benefit from reduced parking.

Reduced Barrier Effect

A parking lot, especially large structured parking in urban areas and surface lots common in suburban office parks, impedes pedestrians, discourages would-be transit riders, and increases out-of-vehicle travel time for both auto and transit users. The amount of building set-back to accommodate parking is specified in site-design guidelines, which are used to promote more pedestrian and transit-oriented communities. The effect of an improved transit- and pedestrian-oriented environment on transit mode share has been quantified for Portland, Oregon, but a measurement of the specific effects of building set-back has not been estimated.[25] Nevertheless, the empirical evidence suggests that transit ridership will increase if distances between transit stations and buildings are short and more pedestrian-friendly.

Fiscal Impacts

Many local governments tax both business activity and parking. Parking, however, is frequently free (thus not taxed) and business activity (and housing) generate considerably more tax revenue per square foot than does paid parking. If a reduction in parking requirements allows for more commercial activity, local jurisdictions should collect a corresponding increase in tax revenues. Estimating the amount of the increase involves a straightforward calculation: the difference between taxes collected on the additional commercial or residential development and the foregone taxes on the paid parking.

Public vs. Private Benefits

Amidst all the analysis of how to estimate the amount of benefit from reduced parking requirements and who captures the benefit, it is easy to overlook the original source of the benefit: public transit. Were it not for the transit agency and the public moneys used to support it, parking requirements would not be possible to reduce. Thus, the direct benefit of reduced parking to a land owner, developer, or tenant is – in effect – a transfer of public spending to private profit. As defined in this study, an *economic* impact due to transit investment generally has been considered a generative impact to the general public, whether that term includes a neighborhood or an entire region.

[25] *The Interrelationships of Land Use, Transportation, and Air Quality (LUTRAQ)*, 1,000 Friends of Oregon, 1991. Cambridge Systematics investigated what effects land use, urban design, and transportation policies would have on future development, travel patterns, and air quality in the region using enhanced travel demand modeling capabilities.

Direct benefit to a specific private entity does not generate significant direct *economic* impact.[26] To create an *economic* impact, the transit agency or some other public jurisdiction must tax some portion (and possibly the full value) of the reduced parking benefits to the private entity and use the revenue to fund the transit improvements (or some other civic project). This approach, known as value capture, ensures that the benefits of transit are realized by the public and users who are ultimately paying for the system's construction and operation.

In many areas, however, transit systems are funded in some part by assessment district revenue. This approach, employing a direct form of value capture, requires landowners to pay either a one-time fee for the system's construction or an annual tax used to retire debt and/or fund operating expenditures. These fees or taxes are then distributed among the land owner, developer, and tenant depending on the market forces discussed in the previous section. When such assessment districts are in effect, and especially when the assessments are set at a rate sufficient to fund a significant amount of the system's capital and operating costs, further taxation of the benefits from reduced parking may not be necessary to recoup the benefits from the private sector.

■ 9.2 Transit-Induced Accessibility and Agglomeration Benefits: Estimation Based on Land Markets

Introduction

The land use impacts of transit investments are widely understood to be largely redistributive. It is well established that, under the right conditions, transit investments can induce shifts in land use activities, leading to compact station area development (Knight and Trygg, 1977; Cervero, 1984). This generally means that urban growth that might otherwise have been oriented around freeway interchanges and along highway corridors instead occurs around transit nodes.

The clustering of activities near rail nodes can mean real economic gains by virtue of the increased accessibility of nearby properties to transit services and the agglomeration economies that accrue. Accessibility gains translate to economic value because time and convenience are worth money. Residents, businesses, and firms bid for choice transit-served locations in a reasonably competitive marketplace. The value of agglomeration is more subtle. Agglomeration benefits represent the economic advantages of compact development. Having certain urban activities (e.g., business services) clustered around transit stations can increase firm productivity and profits through increased face-to-face contact, improved access to specialized skills, and easier external transactions, such as

[26] Indirect and substantially smaller benefits are generated when the beneficiary (land owner, developer, or tenant) spend the money gained from the reduced parking requirement in the regional economy.

subcontracting.[27] Certain goods and services that draw customers from a marketshed also tend to cluster in specific locations according to principles of central place theory; transit stations, for example, can function as nodes for the location of activities that cater to commuters, such as coffee shops, news stands, and dry cleaners.[28]

Large-scale transportation and land use simulation models, like ITLUP and POLIS, are used in larger metropolitan areas to forecast the amount, types, and locations of land use shifts that result from introducing a new regional transit service.[29] These models, however, do not attempt to measure the economic benefits attached to these shifts. Measuring the economic value of concentrated land use activities prompted by transit investments is best accomplished by gauging the land value premiums associated with station area development.

The methods presented in this section involve applying fairly straightforward algebraic formulas that incorporate empirical evidence on the rates of land value premiums as functions of proximity to U.S. transit stations, stratified by different types of transit services, land uses, and urban environments. Given a certain amount of station area land use activity that has either already occurred or is forecasted, these techniques can be used to assign an economic value associated with the resulting accessibility and agglomeration gains.[30] As such, they can be thought of as providing an approach to extracting the generative economic component of concentrated land use development allowed and induced by transit investments. This notion of "nearness" to transit nodes, and the associated economic gain, incorporates concepts of both "accessibility" and "agglomeration." Since clustered development increases both ease and convenience of access and agglomeration-related economic productivity, no attempt is made to separate one from the other. Rather, they are treated jointly, as "accessibility/agglomeration" benefits, by the techniques presented.

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[27] Traditionally, the economics literature has examined agglomeration benefits at the macro level as a basis for explaining the development of big cities and for measuring optimum city size. See Segal (1976) and Henderson (1986). A distinction should be made between "agglomeration" and "urbanization" economics. While agglomeration economies are enjoyed largely by private firms and interests, urbanization economies accrue mainly to the public sector. Urbanization economies represent economies of scale and scope that redound from compact, transit-oriented development, mainly in the form of reduced public outlays for infrastructure (e.g., roads, water trunklines, sanitation, sidewalks, etc.). See Frank (1989), Ewing (1994), and Burchell and Listokin (1995).

[28] Central place theory holds that urban goods and services locate so as to most efficiently serve a minimum threshold of customers, resulting in the formation of overlapping marketsheds whose sizes and ranges systematically vary according to the degree of product or service specialization.

[29] For a description of these models see: *A Technical Review of Urban Land Use-Transportation Models as Tools for Evaluating Vehicle Travel Reduction Strategies*, Frank Southworth, Center for Transportation Analysis, Energy Division. July 1995. Prepared for the Office of Environmental Analysis and Sustainable Development, U. S. Department of Energy. Prepared by Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831. See *http://www.bts.gov/smart/cat/ornl.html* for further information.

[30] As such, the techniques do not measure the degree to which transit investments induce land use changes. Rather, land use shifts are taken as givens. The aim is to assign economic values to these shifts.

This section presents a method for measuring economic benefits that accrue from the increased accessibility and agglomeration that occurs following the opening of a rail transit service. The method does this principally by applying empirical evidence on how transit investments increase urban property values. The methods and applications are limited to rail transit systems since only these investments have been shown in the past to materially increase land values. As such, the method likely will find most application to medium and large-size metropolitan areas that have built or are contemplating investment in light rail, heavy rail, and commuter rail systems.

In the first section below, how proximity to transit gets translated into land values is discussed, including a review of three methods – hedonic price models, matched-pair comparisons, and repeat sales ratios – for measuring land value premiums. Issues related to introducing proper statistical controls, measurement, timeframes of analysis, and contextual setting are also discussed.

Next, a straightforward and transparent method is presented for measuring accessibility and agglomeration benefits based on two inputs: 1) the amount of development occurring in station areas before and after the opening of a rail system; and 2) value premiums associated with specific land uses and defined over distance intervals. A more refined equation also is presented that allows measurement of benefits to be stratified by other dimensions, such as whether stations are located in a CBD or newer suburb. A hypothetical example is then presented that demonstrates the application of the method.

Because the methods presented rely on secondary data inputs, a third section presents the latest empirical evidence on the effects of rail transit investments on land values. Evidence is shown for the following land use categories: single-family/low-density residential; multi-family/medium-density residential; offices; and commercial-retail activities. A series of tables are presented that chronologically summarize the results of past studies, with information provided on measured land value premiums, the spatial extent of premium effects, and the structural form of how premiums vary with distances from stations.

The fourth section applies some of the empirical evidence from the section on rent premiums to demonstrate how methods can be applied to generate estimates of accessibility and agglomeration benefits. The San Francisco BART system is used in the demonstration. Sources of data inputs and additional assumptions needed to carry out the analysis are discussed. Data are then input into equations, and calculations are carried out. Based on the assumptions invoked, it is estimated that the accessibility and agglomeration benefits associated with BART's station area development (for 25 of the system's 36 stations) over the first 20 years of service amounted to around $224 million.

A method of gauging the second-order benefits associated with station area development – namely, the increased ridership and revenues accruing to transit agencies is then described. The method measures how transit modal splits vary as functions of distances to stations. Continuing with the example from BART, the method is applied to arrive at an estimate of around 26,500 daily trips induced by station area development.

Finally, observations are made on the potential usefulness of applying empirical data on transit's land value and capitalization impacts as a basis for measuring accessibility and agglomeration benefits.

Measuring Benefits Based on Land Markets

A central tenet of urban land economics is that site-specific benefits get absorbed, or capitalized, into property values and rents in reasonably well-functioning and competitive land markets (Alonso, 1964; Muth, 1964). In the case of transit, the opening of a new rail station benefits nearby properties since they become more accessible to more places (served by rail transit) within a region. Since the numbers of benefiting parcels are finite, in a competitive marketplace, people and firms bid for these preferred locations, driving up the price of sites. For residential properties, this will mainly reflect accessibility benefits. All things being equal, most Americans want to avoid high-density living, so there likely are little if any agglomeration economies associated with residential growth.[31] Indeed, residents might assign a disvalue to living in compact settings and being "too close" to transit facilities and the street traffic, noise, and fumes they often generate. Offices and commercial-retail activities, on the other hand, can be expected to enjoy both accessibility and agglomeration benefits as a result of compact station area growth.

Before turning to the matter of measuring land-related benefits, several caveats are in order. One, accessibility/agglomeration benefits, as reflected by land values, are generally only conferred by fixed-guideway systems – notably rapid rail (heavy rail), commuter rail, and light rail systems. And it is only around their access points, or stations, that these benefits accrue. (In fact, there may be disbenefit associated with being near a guideway line but not near a station.) As fixed permanent investments that provide relatively high-quality services, rail systems guarantee that properties near stations enjoy accessibility advantages. By operating on surface streets in mixed-traffic conditions, bus services, in contrast, are flexible (meaning services can be re-routed) and generally perceived to be of a lower quality (slower speeds, more random stopping). As a result, their impacts on land uses, and in particular property values, are thought to be more diffuse and in cases even inconsequential. A second caveat has to do with the spatial extent of impacts. It has become somewhat of a rule-of-thumb within the transit industry that the benefits of proximity to rail stations extend around a quarter of a mile radial distance from a station, roughly a distance that can be covered by foot in 5 minutes (Untermann, 1984; Bernick and Cervero, 1997). In reality, the spatial extent of impacts generally taper gradually with distance rather than following a step-like function or ending abruptly at a border. And as shown later, some studies have measured land value impacts well beyond a quarter-mile radius. Even less is known about the functional forms of how land value premiums taper as functions of distance to stations – e.g., whether linear, quadratic, or negative exponential in form.

In applying the techniques presented in this section to a particular metropolitan area and situation, there are at least four other factors that an analyst must consider: 1) controls; 2) measurement; 3) time line; and 4) setting.

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[31] Exceptions, of course, are places like Manhattan where high-rise residential development near centers of entertainment and culture, and which offer views, often command rent premiums. Outside of major commercial districts, however, residential densities are widely viewed as disamenities, all else being equal. Surveys consistently show, for example, that 90 to 95 percent of Americans prefer detached single-family homes to apartments. See Baldassare (1979).

Controls

It does not necessarily follow that if land values rise sharply once a rail transit station opens that the rail services *caused* this appreciation. Jumps in land values could be attributable to other factors, such as an upswing in the regional real estate market, improved highway access, better schools, and so forth. The challenge, then, is to control for these other influences so that the unique effects of transit proximity on land values can be isolated. Three approaches have largely been used to date to separate out the unique effects of proximity to transit on property values and rents: 1) hedonic price models; 2) matched pairs; and 3) repeat sales ratios.

Hedonic price models employ regression analysis to attach a monetary value to different attributes of a property and its surroundings, including the proximity of the parcel to transit. Cross-sectional or time series data, or both, are typically used.[32] Hedonic price models normally follow a general linear form as:

$$P_{i,t} = f(I, N, L)_{i,t}$$

P = Price

I = Vector of attributes of the improvements on the parcel, such as measures of size (e.g., square feet, number of bathrooms), quality, height, age, landscaping, parking, etc.

N = Vector of attributes of the neighborhood, such as quality of public facilities and services (including schools) and socioeconomic composition.

L = Vector of attributes of the location of the parcel, such as distance to CBD, proximity to transportation services (including transit), gravity-based measures of accessibility to labor markets and employment, etc.

i = Cross-sectional observation, representing property transaction i.

t = Time series observation, representing time point t.

Hedonic price models tend to introduce the most rigorous controls. As such, they are widely viewed as providing the most accurate estimates of how access to transit gets capitalized into land values.[33]

Matched pairs rely on finding comparable properties that are in every way similar except one is close to rail transit and the other is not. Finding suitable matches can be difficult.

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[32] Longitudinal, or time series, analyses are generally preferred since the effects of business swings and cyclical patterns can be explicitly controlled. When data for multiple parcels of land are pooled over multiple time periods, it is called a pooled cross-sectional/time series analysis.

[33] Hedonic price models are usually estimated in linear (absolute) and log-linear (proportional, or probability-based) forms. Estimation approaches range from ordinary least squares (OLS) to generalized least squares (e.g., reduced-form estimation).

Thus, comparison properties are rarely similar enough in all respects to suitably isolate the unique effects of proximity to transit. For this reason, matched pairs analyses are usually turned to when data and resources needed to support hedonic price modeling are not available (see Section 4.0).

Repeat sales ratios can also be used to gauge rent premiums. Here, changes in prices and rents between two or more sales transactions for the same transit-served property are recorded. These are compared to price changes for repeat sales of properties unserved by transit to produce a ratio. The differential can be attributed to transit proximity, controlling for other factors (since features of the house, neighborhood, etc. will normally remain constant across time periods).[34]

Measurement

Sales transactions, reflecting what the market will bear, are normally used to gauge the value of land. While the Census reports median home values within tracts, most transaction data are obtained from proprietary local sources (e.g., Black's Guide). Sales transaction data, however, rarely separate the value of land itself from improvements (e.g., buildings).[35] Techniques like hedonic price modeling can be used to separate the marginal value of improvements versus land by including variables describing the size (e.g., square footage) and characteristics (e.g., presence of fireplace, presence of a view) of both improvements and land. Any measurement of the premiums associated with improved accessibility should, in theory, reflect increases in land values or site rents. Another source of information is county assessor records, which normally do distinguish between the values of land and improvements. Since land is usually reassessed only at times of sales transactions, however, assessor records can be spotty and woefully out of date.

Perhaps more problematic are the many discrepancies in the measurement of rents for office and commercial properties. Rents clearly reflect values imparted by both land and improvements as conjunct entities; however, since the interest lies with measuring rent premiums, differentials in rents (between transit-served and non-served properties) should express the capitalized site-related gains from accessibility improvements and agglomeration economies. Normally, only asking rents are reported by brokerage agencies. Asking rents might be expressed on a gross basis (all services included) or a net basis (some services paid for by tenants). Contract rents, which are the product of lease negotiations between individual tenants and landlords, are rarely reported, and can vary substantially from asking rents. Since revenues (and therefore profitability) are based not only on rents but occupancy rates as well, some studies report "effective rents" – average rents adjusted for occupancy rates.[36] Big differences in how rents are measured and

[34] Properties that have been substantially improved over time are usually excluded from the analysis since the improvements, rather than new transit services, could explain increases in real property values.

[35] In theory, the benefits of improved accessibility should be capitalized only into land, or what economists call site rents. In practice, these distinctions are not clearly made.

[36] An office building that rents for $10 per square foot and is 90 percent occupied has an effective rent of $9 per square foot ($10 x 0.90).

reported can confound any analyses that try to attribute rent premiums to accessibility improvements. Because data are most readily available, asking rents has become the *de facto* standard used for expressing commercial rents. However, analysts need to be careful in distinguishing how rents are being measured when applying secondary data sources.

Time Line

The impacts of a rail transit investment can vary dramatically depending upon the timeframe. In some instances, the greatest appreciation in land values occurs prior to the opening of a new system, a consequence of rampant real estate speculation. Increases often occur after plans to site new transit stations are announced but prior to the actual station opening.

Near-term impacts (e.g., rents within the first year or two of opening) might be transitional and thus are not always reliable. A time period of at least five years after the opening of a rail system likely allows sufficient time for land market adjustments to work themselves out and institutional responses (e.g., zoning revisions) to take place. Intermediate and long-term time lines, like moving averages five to 10 years after a service starts, also tend to be less vulnerable to sharp swings and fluctuations in business cycles. While a growing number of studies report on the capitalization impacts of transit for an intermediate and longer-term time horizon, studies normally report results for particular time points rather than the moving averages for a multiyear interval.

Setting

Absolute values of rent and land value premiums (e.g., expressed in dollars per square foot) obviously reflect the particulars of a local real estate market – absolute premiums measured in Sacramento have little transferability to Chicago. For this reason, capitalized premiums are best reported in percentage terms – either as a result of estimating a log-linear hedonic price model (wherein coefficients represent elasticities) or by dividing premium estimates by median rent values (e.g., a $2 per square foot premium in a market averaging rents of $20 per square foot represents a 10 percent premium).

Because regional economies and land markets markedly differ, one should be cautious in applying premiums measured in a particular metropolitan area to another area. To the degree that findings are stratified by land use categories (e.g., residential, commercial-retail, office) and metropolitan setting (e.g., CBD, built-up urban, mature suburban, newer suburban, ex-urban), however, potential errors and biases in transferring findings across regions can be reduced. Stratifying findings across types of transit systems (e.g., heavy rail versus light rail) can also refine the analysis. Heavy rail systems, for example, are thought to exert stronger land use impacts than light rail because they typically serve larger areas, operate at higher speeds, are totally grade-separated, and are controlled centrally.

Measuring Accessibility/Agglomeration Benefits

Land market measures of accessibility/agglomeration benefits can be carried out for both *ex ante* forecasts (of yet-to-be built systems) and *ex post* evaluations (of already completed systems). Two major inputs are needed: 1) *development* – the amount of development (in land area for owner-occupied units, and square footage for rental properties) occurring in station areas before and after the opening of a rail system, either measured or forecasted; and 2) *value premiums* – empirical measures of land value and rent premiums associated with specific land use categories defined over specific distance intervals.

Generalized Methodology

The following equation can be used for estimating accessibility/agglomeration benefits:

$$B = \sum_{k} \sum_{d} \left[(A_{kd} \gamma_{kd}) E_k \right] \quad \text{(Equation 1)}$$

where:

B = Benefit (total, in dollars)

A = Amount of development (land area, floorspace)

γ = Land value or rent premium

E = Expansion factor (rent premiums expressed over benefit period)

k = Land use category

d = Distance category

The formula is applied to the entire impact zone affected by (or expected to be affected by) a rail transit investment. Based on past research or empirical evidence from a comparable area, for example, this might be viewed as the area encompassing half-mile rings around all (existing or planned) rail stations of a particular system.[37]

Applying the Methodology: Inputs

The following inputs are needed to apply Equation 1:

[37] In reality, physical objects and barriers such as rivers and hillsides can affect the actual radius of land value impacts, and such considerations should be accounted for in specific situations. For the sake of simplicity, however, a standard catchment area of a quarter or a half mile radius is often adopted.

1. **Amount of development.** This ideally should be expressed in units for which land value and rent premiums are normally measured.[38] In the case of residential land uses, since premiums are capitalized into land values, the amount of development should be expressed in total square feet (or acreage) of residential land uses, perhaps stratified by single-family (detached) and multi-family (attached) parcels. If lot sizes are fairly comparable across classes of residential uses, development might instead be expressed in terms of total number of units (single-family, multi-family). For non-residential uses (e.g., office, commercial), premiums are normally capitalized into rents, and total rents are pegged to building area; thus, total development should be expressed in terms of floorspace.[39] Additionally, since agglomeration economies normally accrue only to non-residential activities, the amount of development needs to be expressed in terms of building area to reflect the "stacking up" of floorspace that often occurs on a site (e.g., construction of high-rises). When used for forecasting accessibility/agglomeration benefits (e.g., as part of an EIS), this method requires estimates to be made in advance of the amount of development induced by a proposed rail investment. As noted, this information would normally be obtained from a transportation-land use forecasting model, such as ITLUP (DRAM/EMPAL), or some assumptions about the future distribution of population and employment.[40]

2. **Land value and rent premiums.** Premiums are expressed in real dollar terms based on empirical research that extracts the accessibility/agglomeration benefits associated with each land use category and distance interval, controlling for other factors. Land value premiums are used in measuring benefits associated with single-family residences, and rent premiums are used for most non-residential activities. Premiums, then, represent differences in land values and rents *with* versus *without* transit, all else being equal. Since rents are collected on a periodic basis, it is necessary to adjust premiums by an expansion factor that expresses the value for the timeframe of analysis. For example, if benefits are being measured over a 10-year period and rent premiums are expressed on a monthly basis, then these premiums (in constant dollars) should be multiplied by an expansion factor of 120 (12 months * 10 years).

3. **Land use categories.** Breaking down data by land use categories reflects differences in premiums across urban activities. A basic distinction is between residential and non-residential activities. Residential activities might further be stratified by single-family and non-single family. Non-residential activities would normally include two land uses that are thought to benefit from proximity and exposure to transit and

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[38] Note that the amount of development used in calculating benefits should include both preexisting ("without") and transit-induced ("with") activities. That is, existing parcels also reap benefits, not just new ones, since in a competitive land marketplace all properties accruing accessibility and agglomeration benefits capitalize these gains.

[39] Net leasable floorspace ideally should be used; however, in practice, since the cost of constructing, operating, and maintaining unleasable space is passed on to renters, building area is often expressed in terms of gross floorspace.

[40] ITLUP, or the Integrated Transportation-Land Use Program, is the most widely used long-range transportation-land use forecasting model in the United States. DRAM, or the Disaggregate Residential Allocation Model, is used to distribute future residential development across study areas (e.g., census tracts). EMPAL, or the Employment Allocation Model, distributes future employment growth. See Putman (1983).

agglomerations – offices and commercial-retail (e.g., shops, restaurants, consumer services, business services). Land rent theories would suggest, and empirical research largely confirms, that few other non-residential uses, such as industries, accrue benefits from transit-related proximity or agglomerations.[41] Some activities, like hotels, no doubt reap some proximity benefits, though likely only at the high-quality end of the spectrum in specific quarters (e.g., downtown). In instances, airports might reap transit accessibility benefits (e.g., St. Louis's Lambert Field, Atlanta's Hartfield); however, since these sites are generally publicly owned and are not subject to real estate transactions, no studies have ever measured the transit capitalization benefits redounding to airports. In general, empirical evidence on rent premiums for non-residential uses is almost wholly limited to offices and commercial-retail activities.

Refining the Estimates

The calculation of accessibility/agglomeration benefits might be further refined by information on the location of activities within a metropolitan area, area-wide land use densities, and types of transit technologies. This is because land value and rent premiums can significantly vary within these groupings. *Location of activities*, for example, might be broken down by: CBD; urban (e.g., traditional postwar city outside of CBD); mature suburbs (e.g., older suburbs outside of city that grew during early postwar era); newer suburbs (e.g., built on the fringes of metropolitan areas in the past two decades); and exurbs (e.g., satellites of a metropolitan area). While metropolitan rail systems normally impact CBDs, urban districts, and suburbs, commuter rail lines also serve (and thus potentially impact) exurban and rural areas as well. *Land use densities* might be expressed in categories. For residential uses, for example, densities might be trichotomized: low (< 7 dwelling units per acre); medium (7-15 dwelling units per acre); high (> 15 dwelling units per acre). *Types of transit technologies* may be used to stratify data in areas with multiple types of transit system – e.g., heavy and light rail systems. Other breakdowns are conceivable, like whether a rail line is at grade or underground.

A dilemma in refining analyses is that redundancies are likely to be introduced. For example, single-family residential activities are found most often in low-density suburban areas. Thus, stratifying the amount of development and land value premiums by land uses, metropolitan location, and densities invariably introduces overlap. Moreover, as noted later, few empirical studies to date have tried or managed to refine measures of land value or rent premiums by metropolitan location or surrounding densities. Breakdowns by land use categories and transit technologies are about as refined as most capitalization studies get.

Should more refined data become available, however, Equation 1 can easily be extended. For example, say land value and rent premiums are available for the following:

- Land use categories: 1) residential; 2) office; 3) commercial-retail.
- Locational categories: 1) CBD; 2) urban; 3) mature suburb; 4) newer suburb.
- Transit technologies: 1) heavy rail; 2) light rail.
- Distance categories: 1) 0-500 feet; 2) 500-1,000 feet; 3) 1,000-1,500 feet

[41] For a discussion of the land uses experiencing transit capitalization impacts, see Huang (1994).

Thus, the following extended equation could be used for measuring accessibility/agglomeration benefits:

$$B = \sum_{k=1}^{3} \sum_{d=1}^{3} \sum_{m=1}^{4} \sum_{t=1}^{2} \left[(A_{kdmt} \lambda_{kdmt}) E_k \right] \quad \text{(Equation 2)}$$

where:

B = Benefit (total, in dollars)

A = Amount of development (land area, floorspace)

g = Land value or rent premium

E = Expansion factor (rent premiums expressed over benefit period)

k = Land use categories (1,2,3)

d = Distance categories (1,2,3)

m = Location categories (1,2,3,4)

t = Transit technology categories (1,2)

Example

Let's start with a simple hypothetical example. This will be followed later by a more realistic, albeit somewhat more complicated, real-world example. In this initial hypothetical example, say you have been asked to measure the capitalized accessibility and agglomeration benefits associated with a heavy rail transit system that has been in operation for five years. Let's set the base year, just before the rail system opens, at year zero, and our analysis date at year five. (In this case, then, you're studying accessibility/agglomeration impacts over an intermediate timeframe.) Assume you know the following:

- Impact areas extend up to 2,000 radial feet in all directions from rail station entrances.
- Land uses reaping accessibility and/or agglomeration benefits are limited to two: 1) residential; and 2) commercial.
- Land value and rent premiums are known for each land use category for four specific distance intervals from stations: 1) 0-500 feet; 2) 500-1,000 feet; 3) 1,000-1,500 feet; and 4) 1,500-2,000 feet.
- Before carrying out the calculation, we'll need two inputs: 1) amount of development; and 2) land value and rent premiums.

Amount of Development

For all affected station areas, the *amount of development* is distinguished "with" versus "without" the transit system. The simplest way to distinguish the two is to define the "without" time point as being before the system opened, and "with" as being after the system opened (in our example, five years after). (This approach assumes no development would have occurred in the impact zones in the absence of building and opening the system.) Alternately, one could estimate "without" amounts of development in year five based on either simulated outputs from transportation-land use models, or by extrapolating past trends.[42] "With" amounts of development are known from land use inventories. In our example, the following "with" and "without" amounts of development shown in Table 9.4 (and also in Figures 9.1 and 9.4) were estimated.

Table 9.4 Total Amount of Development, With and Without Rail System

	Residential (Land Area, 1,000 sf.)			Commercial (Floorspace, 1,000 sf.)		
Distance Interval (ft.)	**Without**	**With**	**Total**	**Without**	**With**	**Total**
0 – 500	250	200	450	20	140	160
500 – 1,000	350	500	850	50	70	120
1,000 – 1,500	600	800	1,400	40	60	100
1,500 – 2,000	700	1,000	1,700	30	50	80

These amounts are reflective of how land development might occur around rail transit stops, barring zoning and other regulatory restrictions. Most residential development, in particular single-family housing, will occur in the outer rings of an impact zone partly because outer rings encompass larger land areas and partly because sites more immediate to stations will likely be occupied by commercial activities as the "highest and best uses."[43] Because of agglomeration economies and advantages of easy access, most commercial development will concentrate in the inner ring (in the form of higher rise buildings), even though the inner ring has just one-seventh the land area of the outer ring.[44] Note from Table 9.4 and Figure 9.11 that the greatest amount of transit-induced development is for

[42] Assume, for example, that the base year (when the rail system opened) is year zero and the analysis is being conducted for five years after the base year. If the average annual increase in residential development was two percent in areas that are designated "impact zones," then the base amount of residential development "without" rail would be assumed to increase by 10 percent (5 * 2 percent), assuming growth occurs linearly (at a non-compounding rate).

[43] Each of the rings encompasses the following land areas: 0-500 feet = 18.03 acres; 500-1,000 feet = 54.09 acres; 1,000-1,500 feet = 90.15 acres; and 1,500-2,000 feet = 126.21 acres.

[44] However, since the absolute size of land area in the outer ring is so much larger than the inner one, the differential in total amount of commercial development is moderated.

commercial floorspace within the 500-foot ring of the station, reflecting the tendency for rail transit systems to attract concentrated office and retail development.

Figure 9.11 Example: Amounts of Residential Land Development by Distance to Transit Station

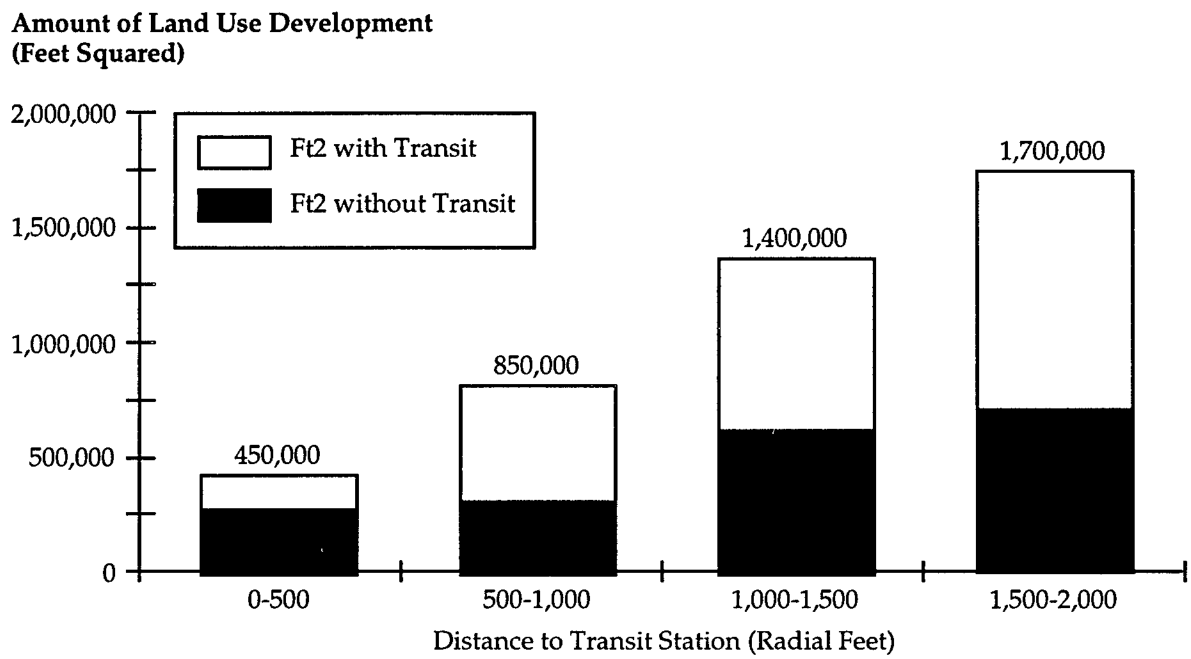


Figure 9.12 Example: Average Residential Land Values by Distance to Transit Station

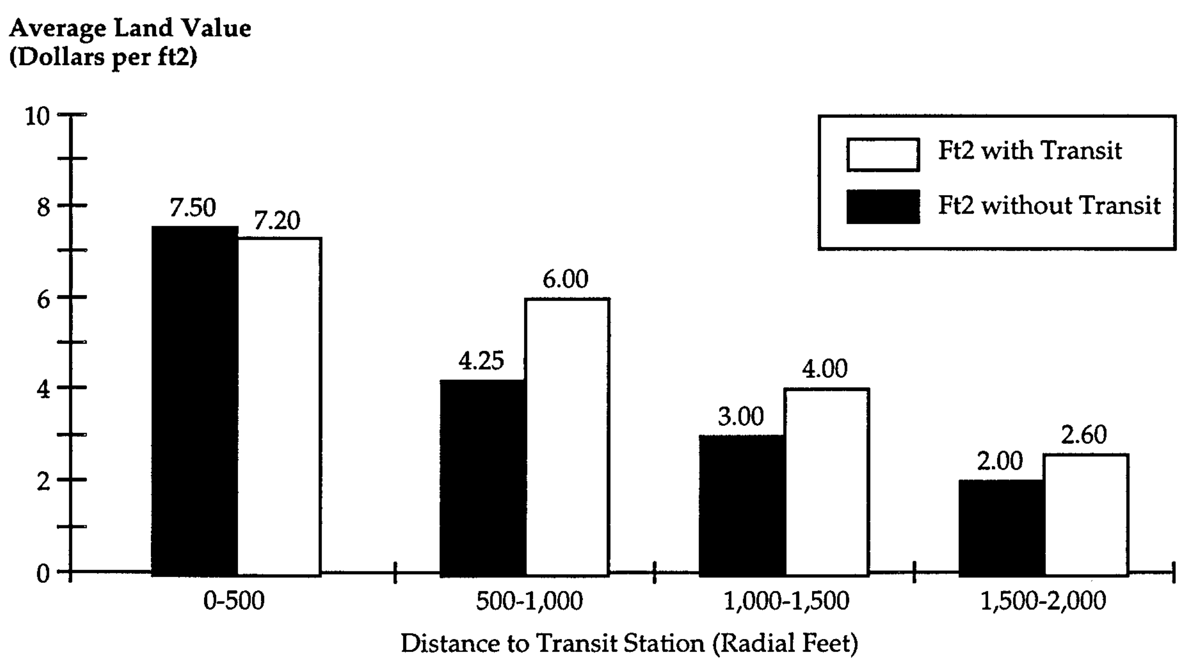


Figure 9.13 Example: Residential Land Value Premiums by Distance to Transit Station

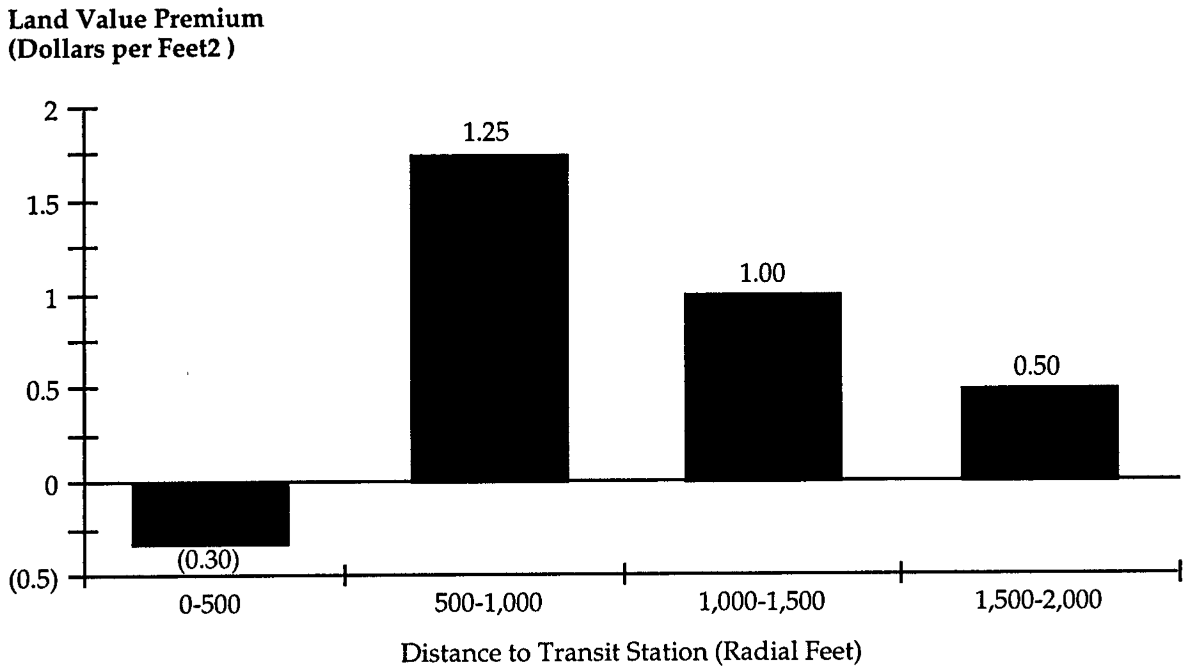


Figure 9.14 Example: Amounts of Commercial Land Development by Distance to Transit Station

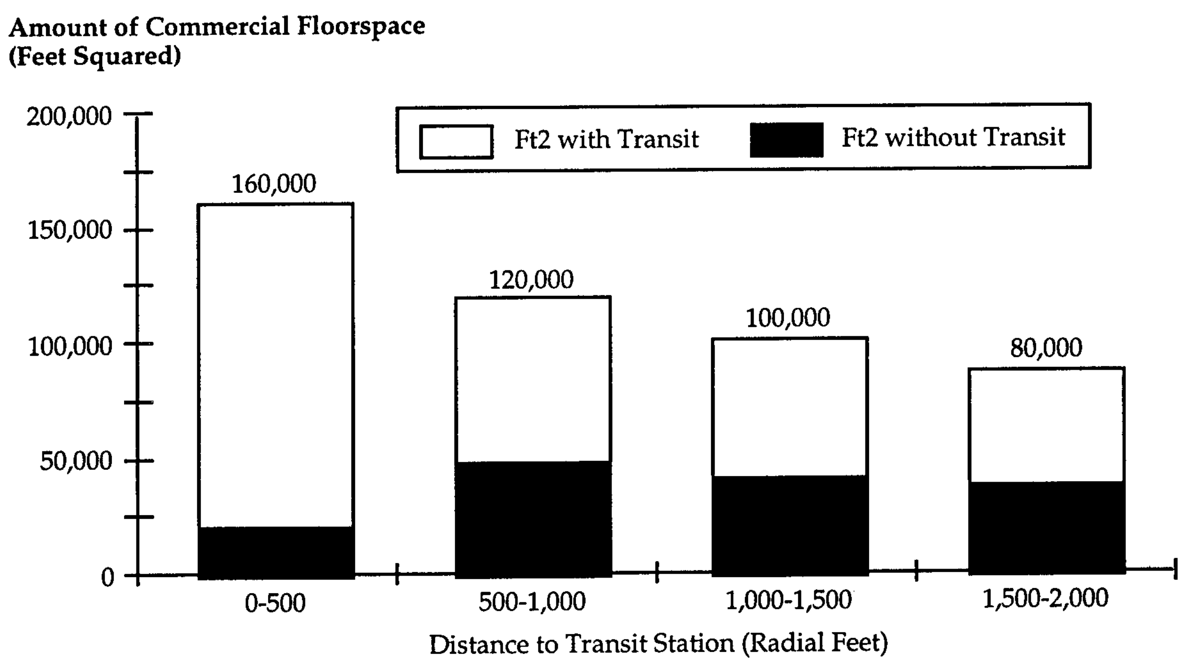


Figure 9.15 Example: Average Commercial Rents by Distance to Transit Station

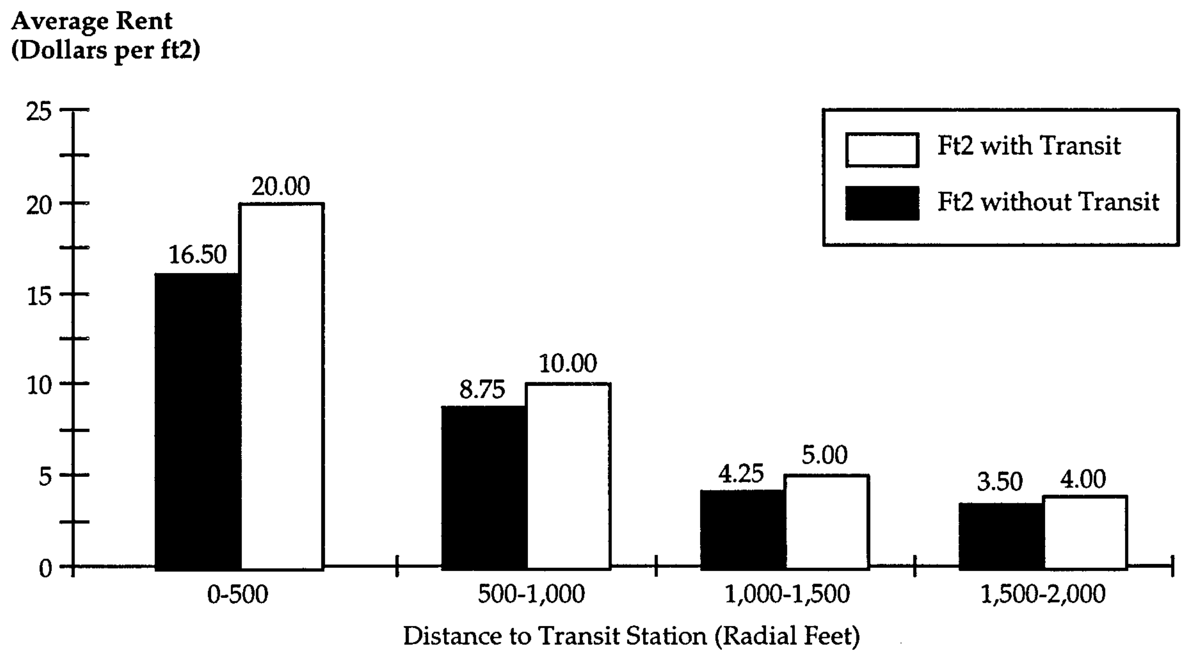
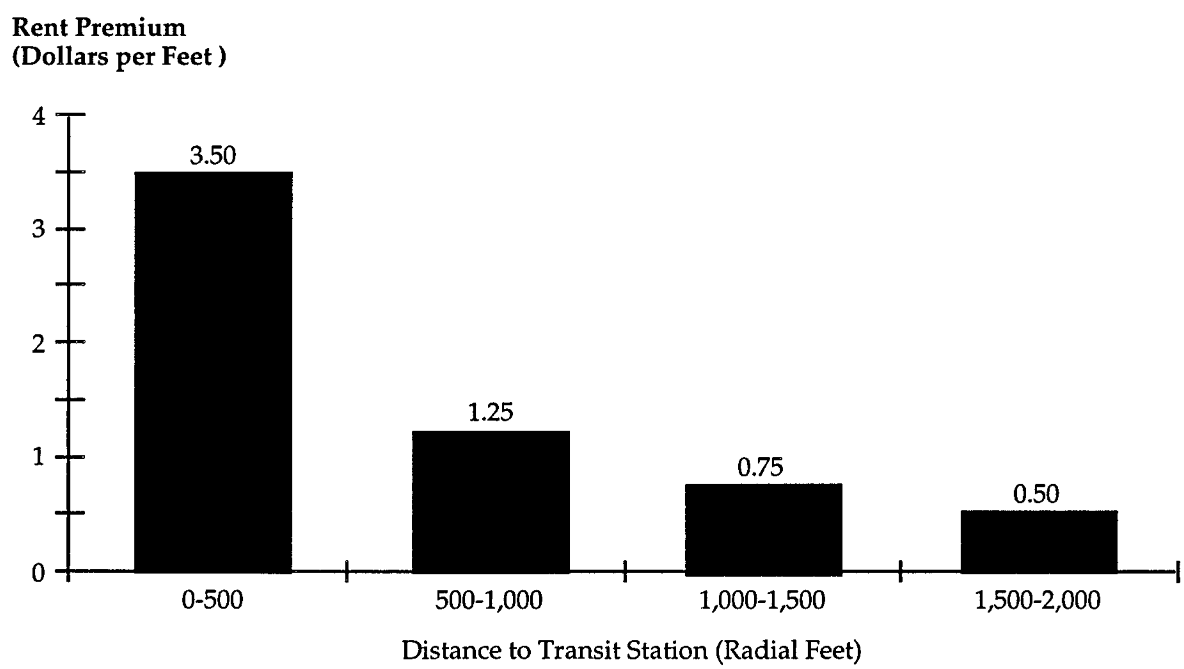


Figure 9.16 Example: Commercial Rent Premiums by Distance to Transit Station



Land Value and Rent Premiums

For our example, let's assume that past hedonic price models estimated for both residential and commercial land uses in our area successfully separated the unique effects of transit proximity on land values and rents, controlling for the influences of other explainers.[45] From these models, the average residential land values and commercial rents were estimated for each of the distance categories, shown in Table 9.5 (and in Figures 9.2 and 9.5).[46]

Table 9.5 Average Land Value and Rent Premiums for Distance Categories, With and Without Rail System

	Residential (Average Land Values, $/SF.)			Commercial (Average Rents, $/SF./mo.)		
Distance Interval (Feet)	**Without**	**With**	**Total**	**Without**	**With**	**Total**
0 – 500	7.50	7.20	-0.30	16.50	20.00	3.50
500 – 1,000	4.50	6.00	+1.50	8.75	10.00	1.25
1,000 – 1,500	3.00	4.00	+1.00	4.25	5.00	0.75
1,500 – 2,000	2.00	2.60	+0.60	3.50	4.00	0.50

Figure 9.13 summarizes the average land value premiums for residential uses, and Figure 9.16 summarizes the average rent premiums for commercial activities. As shown in Figure 9.13, there is disvalue associated with residences being too near a rail transit station. In real dollar terms and controlling for other changes, properties within 500 feet of an existing station were worth, on average, $0.30 more per square foot prior to the initiation of rail services. The highest land value premiums are shown to be within the 500-1,000-foot ring around rail stations – a distance sufficiently buffered from the noise and street traffic generated by rail services but still conveniently accessible by foot. Beyond the 500-1,000-foot range, premiums taper with distance from stations, at a fairly linear rate, and disappear beyond 2,000 feet. Figure 9.16 shows a different relationship for commercial uses. There is no disvalue associated with very close proximity; in fact, commercial buildings closest to rail stations average the highest rents, all else being equal. Rent premiums decline with distance from stations at a decreasing rate – i.e., rent premiums follow an exponential decay function in relation to distance from stations.

[45] Ideally, these would be the results of a pooled time-series/cross-sectional analysis, with data observations drawn from property transactions for times points before and after the opening of the rail transit system and in locations within, as well as beyond, the 2,000 foot impact zone.

[46] These represent the estimated values and rents based on observations (e.g., sales transactions) that include (e.g., "with") versus do not include (e.g., "without") nearby rail services, *ceteris paribus*.

Calculation

Applying data in Tables 9.4 and 9.5 to Equation 1 allows the accessibility/agglomeration benefits associated with the rail transit investment to be estimated. Again, benefits are being measured for an intermediate period – zero to five years after the opening of the rail system. No time adjustment is necessary for residential land uses, since for each parcel, the benefit is capitalized into land value as a one-time effect. In the case of commercial land uses, however, an expansion factor needs to be applied to adjust monthly rent premiums to a five-year period. If the amount of transit-induced land development that occurred month-by-month during the year zero to year five period was known, then monthly totals could be multiplied by premiums and accumulated over time to arrive at precise estimates. In practice, however, land use inventories are only gathered for two time points (e.g., before and after services start). As a result, an estimate needs to be made of the average length of time new (transit-induced) commercial floorspace has been in existence over the study period, in our case, from year zero to year five. In the absence of better information, one can assume that new commercial development occurred uniformly over the five-year, or 60-month, evaluation period, meaning that, on average, new station area shops and offices were on the market for 30 months of the 60-month study period. Thus, an Expansion Factor of 30 can be applied for commercial land uses in this example. Using this Expansion Factor with other inputs results in the following estimates:

$$Benefit_{residential} = (450{,}000 \times -\$0.30) + (850{,}000 \times \$1.50) + (1{,}400{,}000 \times \$1.00) + (1{,}700{,}000 \times \$0.60) = \$3{,}560{,}000$$

$$Benefit_{commercial} = (160{,}000 \times -\$3.50) + (120{,}000 \times \$1.25) + (100{,}000 \times \$0.75) + (800{,}000 \times \$0.50) \times 30 = \$24{,}750{,}000$$

$$Total\ Benefit = \$3{,}560{,}000 + \$24{,}750{,}000 = \$28{,}310{,}000$$

Empirical Evidence on Rent Premiums

The methodology presented for estimating accessibility/agglomeration benefits relies on empirical evidence regarding transit's capitalization effects on land values and rents. Fortunately, a number of studies have been conducted over the past few decades that provide a reasonably reliable basis for applying these techniques, at least for some metropolitan areas of the country. Because measuring transit's effects on land values and rent premiums can be very data and time intensive, one should first look to borrow from the investments and findings of other researchers.

From an extensive literature review, it was found that past transit capitalization studies divided into two types of transit technologies and four types of land uses.[47] The two transit types are: 1) rapid rail/commuter rail/advanced light rail, representing fast, grade-separated, and geographically extensive services; and 2) conventional light rail, representing slower, sometimes shared right-of-way, and geographically more restricted

[47] Literature summaries of transit capitalization impacts can also be found in: Joint Center for Urban Mobility Research (1987); Huang (1994); and Cervero and Seskin (1995).

services.[48] In general, the capitalization effects of higher-performing rapid rail/commuter rail/advanced light rail services have been greater than those of light rail systems, as would be expected. (Note that no capitalization studies could be found for bus-based transit systems.) The four types of land uses are: 1) single-family/low-density residential; 2) multi-family/medium-density residential; 3) office; and 4) commercial-retail. Single-family residential represents detached units, mainly in low-density suburban settings (although many studies include older single-family homes in built-up urban areas as well). Multi-family residential consists of duplexes, townhouses, apartments, and condominiums; while most represent moderate density settings, it is difficult to generalize about their locations since empirical data come from all kinds of urban and suburban environments.

Overall, the literature failed to sort findings on land value and rent premiums into clear categories of metropolitan setting (e.g., downtown, urban, mature suburbs, new suburbs, exurbs). This is partly because most capitalization models were estimated using properties drawn from throughout a region. As noted, certain land uses are easier to associate with a metropolitan settings than others. While capitalization premiums measured for single-family homes generally represent suburban settings, for example, it is difficult to separate whether premiums measured for offices are for downtowns, built-up urban districts, or new suburbs. Hedonic price models for office capitalization rates are usually based on asking rents obtained from offices throughout a metropolitan area.

Tables 9.6 through 9.11 summarize key information and findings, including measured premium effects, from capitalization studies conducted for U.S. and Canadian rail transit services since 1970.[49] While capitalization studies were conducted prior to 1970, these were done largely for older (often turn-of-the-century) rail systems and did not always introduce suitable controls. All of the studies summarized in Tables 9.6 through 9.11 introduced statistical controls to some degree. Under each of the six combinations of transit and land use types, studies are listed in chronological order. In addition to the author, date of study release or publication, and system(s) studied, the following information is shown:

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[48] Rapid rail transit, sometimes called heavy rail or metros, are high-speed, high-performance systems within urbanized areas that connect neighborhoods and major activity centers to downtowns. They are electrically propelled, usually from a third rail, and each car has its own motor. Commuter rail transit typically links outlying towns and suburbs to a region's downtown. These systems are characterized by heavy equipment (e.g., locomotives that pull passenger coaches), wide station spacing, and high maximum speeds that compete with cars on suburban freeways, though slow in acceleration and deceleration. Conventional light rail, sometimes also called streetcars and trams, often operates in mixed-traffic settings and obtains electricity from an overhead wire instead of a middle third rail. Light rail normally operates over a more limited geographic area. A hybrid of light and heavy rail is what is called advanced light rail, or intermediate capacity transit (ICT), represented by Vancouver's SkyTrain system. For more details on transit technologies, see Black (1995).

[49] The lion's share of capitalization studies to date have been for rail systems in the United States and Canada. While similar studies can be found for rail services in the United Kingdom and other parts of Europe, they are not reported here because of fundamental historical, social-cultural, and political differences between much of Europe and North America.

Table 9.6 Summary of Transit Capitalization Studies
Transit Type: Rapid Rail/Commuter Rail/Advanced Light Rail
Land Use Type: Single-Family/Low-Density Residential

Author (Date)/ System	Analysis Technique	Dependent Variable	Time Context	Transit Accessibility Measure	Premium Effect (1997 US$)	Spatial Extent of Effect (ft.)	Structural Form of Distance	Control Variables/Comments
Davies (1970) San Francisco BART	RSR	SF home sales price	Pre-project	Linear ft. to station	New suburbs: 2 to 14%	800	Linear	No controls; comparison of average repeated sales price for properties near station versus within six- block area of station
Dornbush (1975) San Francisco BART	MP/BA	SF home sales price	First year of operations	Distance category	New suburbs: 0-400 ft.: -4%	1,500	Binary	Comparisons with subregional markets; for newer suburban communities with P&R BART
Dewees (1976) Toronto	HP	SF home sales price	Post-construction; > 5 years	Time cost, converted to distance	Mature urban: +$7,500, or +18%, per mile walk closer to station	1,750	Uniform within sphere	Rich array of housing quantity, quality, and neighborhood attributes; value of time weighted for travel, wait, walk
Falcke (1978) San Francisco BART	RSR		Post-construction; > 3 years	Linear ft. to station	Mature suburbs: +$1.35/ft.^{2} for each ft. closer to some stations	1,000	Linear	Distances to shopping and BART tracks for some stations (not all)
Dyett et al (1979) San Francisco BART	MP	SF home sales price	First 1-2 years of operation	Distance category	Mature urban/residential 0-500 ft.: +17% 500-1,000 ft.: +5% 1,000-1,500 ft.: +3% 1,500-2,000 ft.: +2% 2,000-2,500 ft.: +1% Mature urban/mixed-use: None	1,500	Negative exponential	Comparisons with subregional markets; for mature urban communities with limited parking
Damm et al. (1980) Washington Metrorail	HP	SF home sales price	Pre-project	Linear ft. to station	-0.06-.13 distance elasticity	2,500	Reciprocal straight-line distance	Neighborhood quality, densities, and socioeconomics; zoning compatibility

Table 9.6 Summary of Transit Capitalization Studies
Transit Type: Rapid Rail/Commuter Rail/Advanced Light Rail
Land Use Type: Single-Family/Low-Density Residential (continued)

Author (Date)/ System	Analysis Technique	Dependent Variable	Time Context	Transit Accessibility Measure	Premium Effect (1997 US$)	Spatial Extent of Effect (ft.)	Structural Form of Distance	Control Variables/Comments
Bajic (1983) Toronto Spadina Line	HP	SF home sales price	Post-construction; > 10 years	Weighted commute time via rail to 5 destinations	Inner-urban:+$5,370 per housing unit (single commuter)	Large catchment (no precise distance)	Linear	Array of housing, neighborhood, locational attributes; weighted commuting times to multiple locations; rich mix of controls
Allen et al (1986) Philadelphia-NJ Lindenwold High Speed	HP	SF home sales price	Post-construction; > 5 years	Commute cost savings to CBD	$665/dollar commute cost savings; $6,870 or +7.8% per unit	~10,000 (transit-served census tracts)	Linear	Lot size, building type and stories, property tax, dummies for housing amenities; distance to Camden and major bridges; for mainly suburban New Jersey development
Ferguson et al. (1988) Vancouver SkyTrain	HP	SF home sales price	Pre-project	Linear ft. to station	+$14.70/sf for each ft. closer to station	2,400	Linear	Array of housing, neighborhood, locational attributes; interaction terms; secular time trend

Note: HP = Hedonic Price Model; MP = Matched Pair Comparisons; P&R = Park-and-Ride; RSR = Repeat Sales Ratios; SF = Single Family

Table 9.7 Summary of Transit Capitalization Studies
Transit Type: Rapid Rail
Land Use Type: Multi-Family/Medium-Density Residential

Author (Date)/ System	Analysis Technique	Dependent Variable	Time Context	Transit Accessibility Measure	Premium Effect (1997 US$)	Spatial Extent of Effect	Structural Form of Distance Effect	Control Variables/Comments
Falcke (1978) San Francisco BART	RSR	Monthly rents	Post-construction; > 5 years	Linear ft. to station	None, except Walnut Creek Station area	1,000	Linear	Comparable distances to BART tracks as a control
Damm et al. (1980) Washington Metrorail	HP	MF residential sales price	Pre-project	Linear ft. to station	-0.19 price elasticity relative to distance	2,500	Linear	Neighborhood quality, densities, and socioeconomics; zoning compatibility
Rybeck (1981) Washington Metrorail	MP	Condominium sales price	Post-construction; 1-3 years	Distance category	\$16.90 to \$18.60 per ft.^{2} within 1/4 mile	1,320	Binary	Comparably aged and sized suburban condominiums within versus beyond 1/4 mile. Examined for Arlington station areas
Bernick & Carroll (1991) San Francisco BART	MP/I	Monthly rents	Post-construction; > 15 years	Distance category	+5%	1,320	Binary	Rent comparisons of "comps" based on advice of local real estate brokers
Bernick et al. (1994) San Francisco BART	MP	Monthly rents	Post-construction; > 15 years	Distance category	\$0.05 per sf per month	1,320	Binary	Compared units within and beyond 1/4 mile of stations, matched by age, submarket, and bedroom-bathroom sizes. Suburban station areas
Cervero (1996) San Francisco BART	HP	Monthly rents	Post-construction; > 15 years	Distance category	\$42.30 per unit per month; \$0.04 per sf per month	1,320	Binary	Attributes of apartment complex and units; project age; city dummy

Notes: HP = Hedonic Price Model; I = Interview; MP = Matched Pair Comparisons; RSR = Repeat Sales Ratios; MF = Multi-Family

Table 9.8 Summary of Transit Capitalization Studies
Transit Type: Rapid Rail
Land Use Type: Office

Author (Date)/ System	Analysis Technique	Dependent Variable	Time Context	Transit Accessibility Measure	Premium Effect (1997 US$)	Spatial Extent of Effect (ft.)	Structural Form of Distance Effect	Control Variables/Comments
Falcke (1978): San Francisco BART	RSR	Office rents	Post-construction; > 3 years	Linear ft to station	Oakland CBD: 0-600 ft: 10%; 600-1000 ft : 4%; > 1000 ft: None San Francisco CBD: 0-1% Walnut Creek: 0-200 ft: 6%; > 200 ft: None	Varies	Binary	Straightline distances to BART stations; Oakland impacts only for new office buildings; Walnut Creek impacts only for buildings adjacent to BART station.
Rybeck (1981): Washington Metrorail	MP	Office rents	Post-construction; 3-4 years	Distance category	(1) Downtown Washington: +$3.60/ft^2 or 9% (2) Montgomery County (Silver Spring): +$3.25 per ft^2, or 14%	300	Binary	Matched pairs near and away from Metro stations based on interviews with real estate brokers and developers
Cervero (1993): Washington Metrorail; Atlanta MARTA	HP	Office rents	Post-construction; > 5 years	Distance category	+$3.58/ft^2 or 13.7%	300	Binary	Premium measured for joint development office projects adjacent to mature suburban Metrorail and MARTA stations.
Cervero and Landis (1993): Washington Metrorail; Atlanta MARTA	MP	Office rents	Post-construction; > 5 years	Distance category	(1) Metrorail: +$4.24 to+$5.35 ft^2, or +12.3% to 19.6% (2) MARTA: +$2.80 to +$4.59 ft^2, or +11% to 15.1%	300	Binary	Comparisons of rent premiums for offices that were jointly developed with rail stations. Premiums averaged over 12 year periods.
Landis and Huang (1995): San Francisco BART	RM	Sale price for office properties	Post-construction; > 10 years	Distance categories	None None	1300 2600	Binary	Lot and building area, city and transaction year dummies; measured for within 1/4 and 1/2 mile of East Bay stations.

Notes: HP = Hedonic Price Model; MP = Matched Pair Comparison; RM = Regression Model; RSR = Repeat Sales Ratio.

Table 9.8 Summary of Transit Capitalization Studies
Transit Type: Rapid Rail
Land Use Type: Office (continued)

Author (Date)/ System	Analysis Technique	Dependent Variable	Time Context	Transit Accessibility Measure	Premium Effect (1997 US$)	Spatial Extent of Effect (ft.)	Structural Form of Distance Effect	Control Variables/Comments
Landis and Lotzenheimer (1995): San Francisco BART	HP	Office rents	Post-construction; > 15 years	Distance categories: 1/8 mi. intervals for 0 to 1/2 mi.	(1) Downtown San Francisco: None (2) Downtown Oakland: None (3) Walnut Creek (Suburb): None for 0 to 1/4 mile; +$0.28 per ft^2, or 16%, for 1/4 to 3/8 mile	2000	Multinomial (4 ordinal distance categories)	Building variables, including size, age, heights, parking; market vacancy and rent variables.
Bollinger et al. (1996): Atlanta MARTA	HP	Office rents	Post-construction; > 10 years	Distance category	-$0.95, or -4%, per ft^2	1300		Array of building, site, locational, socioeconomic, accessibility factirs, including gravity measure of proximity to residences of worker clases; 190, 4994, 1996 time points.

Notes: HP = Hedonic Price Model; MP = Matched Pair Comparison; RM = Regression Model; RSR = Repeat Sales Ratio.

Table 9.9 Summary of Transit Capitalization Studies
Transit Type: Rapid Rail
Land Use Type: Commercial-Retail

Author (Date)/ System	Analysis Technique	Dependent Variable	Time Context	Transit Accessibility Measure	Premium Effect (1997 US$)	Spatial Extent of Effect (ft.)	Structural Form of Distance Effect	Control Variables/Comments
Falcke (1978): San Francisco BART	RSR	Sale price for retail establishments	Post- construction; > 3 years	Linear ft to station	Mature urban: 0-500 ft: 1%; > 500 ft: None Suburban: 0-1000 ft: 8%; > 1000 ft: None	Varies	Binary	Straightline distances to BART stations and downtown San Francisco rail station.
Damm et al (1980): Washington Metrorail	HP	Sale price for retail establishments	Pre-project	Linear ft to station	-0.69 price elasticity relative to distance	2500	Linear	Neighborhood incomes, parking supply, degree of parcel upgrade, measures of employment densities.
Landis and Huang (1995): San Francisco BART	RM	Sale price for retail properties	Post- construction; > 10 years	Distance categories	None None	1300 2600	Binary	Lot and building area, city and transaction year dummies; measured for within 1/4 and 1/2 mile of stations.

Notes: HP = Hedonic Price Model; RM = Regression Model; RSR = Repeat Sales Ratio.

Table 9.10 Summary of Transit Capitalization Studies
Transit Type: Light Rail
Land Use Type: Single-Family/Low-Density Residential

Author (Date)/ System	Analysis Technique	Dependent Variable	Time Context	Accessibility Measure	Premium Effect (1997 US$)	Spatial Extent of Effect (ft.)	Structural Form of Distance Effect	Control Variables/Comments
VNI Rainbow (1992) San Diego Trolley	MP	SF home sales price	Post-construction; > 3 years	Distance category; adjacency or not	2%	200 (adjacent to station)	Binary	Comparison of properties very near versus within 2,600 ft. of stations that are otherwise similar
Al-Mosaind et al. (1993) Portland MAX	HP	SF home sales price	Post-construction; > 5 years	Distance category	$5,360 or 10.6% per unit	1,500	Linear	Array of housing and locational attributes; no neighborhood controls except zoning
Landis et al. (1995) (1) Sacramento Light Rail	HP	SF home sales price	Post-construction; 1-2 years	(1A) Linear ft. to station	$806, or 0.4%, for every 1,000 ft. closer to station	~25,000	Linear	Various housing size, age, and amenity attributes; tract income and socioeconomies; highway distance
				(1B) Distance category	+$11,990, or 6.2%, per unit within 900 ft. of station	900	Binary	Wide variations across light rail systems; adjacency premiums in Sacramento, and adjacency disamenities in San Diego and Santa Clara County
(2) San Diego Trolley	HP	SF home sales price	Post-construction; >3 years	(2A) Linear ft. to station	$337, or 0.1%, for every 1,000 ft. closer to station	~25,000	Linear	
				(2B) Distance category	-$10,410, or -4.1%, per unit within 900 ft. of station	900	Binary	
(3) Santa Clara County Light Rail	HP	SF home sales price	Post-construction; 1-2 years	(3A) Linear ft. to station	$324, or 0.1%, for every 1,000 ft. closer to station	~25,000	Linear	
				(3B) Distance category	-$38,970, or -10.8%, per unit within 900 ft. of station	900	Binary	

Note: HP = Hedonic Price Model; MP = Matched Pair Comparisons

Table 9.11 Summary of Transit Capitalization Studies Transit Type: Light Rail Land Use Type: Other Land Uses

Author (Date)/ System	Analysis Technique	Dependent Variable	Time Context	Transit Accessibility Measure	Premium Effect (1997 US$)	Spatial Extent of Effect (ft.)	Structural Form of Distance Effect	Control Variables/Comments
Multi-Family Housing								
VNI Rainbow (1992) San Diego Trolley	MP	Apartment rents	Post-construction; > 3 years	Distance category; adjacency or not	0 to $3,475 per unit, or 0 to +5%	200 (adjacent to station)	Binary	Rent premium from higher occupancy rates in La Mesa project adjacent to trolley line
Offices								
VNI Rainbow (1992) San Diego Trolley	MP	Office rents	Post- construction; > 3 years	Distance category; adjacency or not	None	200 (adjacent to station)	Binary	Comparison of per square foot rents with control property; suburban offices
Landis and Huang (1995) San Diego Trolley	RM	Sales price for office properties	Post- construction; > 3 years	Distance category	(1) None (2) None	(1) 1,300 (2) 2,600	Binary	Lot and building area, lot and transaction year dummies; measured for within 1/4 and 1/2 mile of downtown and suburban stations from 1987-1993
Commercial-Retail								
VNI Rainbow (1992) San Diego Trolley	MP	Retail rents	Post- construction; > 8 years	Distance category; adjacency or not	+$1.35 per sf, or +167%	200 (adjacent to station)	Binary	Comparison of per square foot rents with control property 1/2 block away; downtown shops

Note: MP=Matched Pair Comparisons; RM=Regression Model.

- **Analysis technique:** The major tools used for measuring capitalization effects have been hedonic price models, matched pairs, and repeat sales ratios. As noted in the last column of each table, studies vary markedly in approach and degree of sophistication with regards to introducing controls.

- **Dependent variable:** Most studies of single-family homes have measured premiums based on market prices, recorded through sales transactions. Premiums for apartments and other multi-family housing are normally based on monthly rents. Office values are also usually expressed on the basis of monthly rents (per square foot), though some studies have been based on sales prices. For commercial-retail activities, values have usually been expressed on the basis of sales transaction prices.

- **Time context:** Studies vary quite a bit in terms of the length of time capitalization effects were measured following the opening of a system. For several studies of single-family sales, effects were measured pre-project – i.e., before the system opened. The majority of capitalization studies, however, have been conducted for intermediate to long-term time spans, periods over which market adjustments to new rail services should have stabilized.

- **Transit accessibility measures:** Most studies have measured accessibility to rail stations on the basis of either straight-line (linear) feet to a station entrance, or by using a distance category (e.g., a dummy variable signifying whether or not a property lies within 1,000 feet of a station). Several studies have expressed transit accessibility on the basis of travel time or commute cost savings.

- **Premium effects:** Premium effects have been reported in numerous forms, making generalizations difficult. Many studies have simply reported premiums (or disvalues) on a dollar per square foot or per housing unit basis. To make findings more comparable, rent premiums have been converted to 1997 U.S. dollars by using the consumer price index (CPI), where possible.[50] Ideally, premiums are reported in percentage terms (relative to mean property values), thus facilitating the transfer of findings to other areas. Premiums reported in dollar values have been converted to percentage terms where possible, using mean values reported in studies or by the U.S. Census Bureau. Some premiums are expressed in elasticity terms – percentage change in rents per unit increase in distance from stations. As noted, most capitalization studies fail to distinguish the metropolitan settings for which the findings were measured. Where the settings are defined or can be discerned, they are presented in these tables. Also, many studies fail to measure rent or land value premiums for multiple distance intervals, thus it is difficult to infer any kind of distance-from-station gradient from many capitalization studies. The best information on premium gradients as functions of distances from stations come from San Francisco's BART system. For some other systems, like MARTA, capitalization effects across distance categories can be imputed by

[50] The CPI, estimated by the U.S. Bureau of Labor Statistics, is for all goods and services, not just real estate. The CPI is assumed to increase by 3 percent in calendar year 1997. Canadian dollars are expressed as U.S. currency depending on the exchange rate for the years encompassing the analysis of capitalization effects.

inputting data into estimated hedonic price models and comparing value estimates with median prices of housing units.[51]

- **Spatial extent of effects:** The catchment areas of recorded capitalization impacts also vary markedly across studies. Many define the capitalization effects of transit proximity within 1,000 to 1,500 feet of a station, or roughly within a quarter-mile distance or five-minute walk. Nevertheless, some have found impact areas to extend a number of miles away from a station – what one might expect for suburban and terminal station areas where park-and-ride lots draw customers from a large catchment. The land value premiums associated with large catchments, however, are mostly limited to residential uses and are generally thought to erode to inconsequential levels beyond several miles from a station.

- **Structural form of distance effect:** Because distances from stations are normally measured in linear feet or in terms of categories, premium effects have generally been measured in simple linear or binary forms. With the exception of several studies of single-family housing values associated with San Francisco's BART and Atlanta's MARTA (that explicitly fit negative exponential or quadratic curves to data), most nonlinear forms have been implicitly captured by measuring average premiums for distinct distance categories.

- **Control variables:** Studies have varied substantially in the degree to which control variables are used for other possible explainers of land values and rents, besides proximity to transit. Hedonic price models of land value premiums for the Philadelphia Lindenwold line, Toronto's Metrorail, Atlanta's MARTA, and San Francisco's BART, in particular, have been vigorous in their use of control variables, and thus provide some of the most reliable evidence available. Studies of light rail's impacts on non-residential rents (Tables 9.8 and 9.9) have generally been the least successful in controlling for other possible explainers.

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[51] In the case of Nelson's 1992 evaluation of MARTA's impacts on single-family home prices, for instance, capitalization impacts were estimated as follows. Quadratic expressions of distance to stations as predictors of sales prices were used to determine the "break-even" distance at which mean sales prices would be equivalent to the price of a housing unit situated exactly at the station site, all else being equal. In the case of the lower-income, minority-populated southern sections of the elevated East Line, it was determined that the concave quadratic expression produced a zero value at about 6,700 feet, or one and a quarter miles, from the station entrance. (This is based on coefficients of -1,045.6 for distance, expressed in 100 foot units, and +15.56 on distance-squared: $[-1{,}045.6*67] + [15.56*67^2] =\sim 0.$) For distance intervals within this range, land value differentials were inferred by comparing mean values between properties located at the break-even point and those within distance intervals.

Real-World Example: Measuring BART's Accessibility and Agglomeration

Benefits

Given the current state of knowledge, it is difficult to generalize about transit's capitalization effects because studies vary so widely in terms of methodologies, measurement units, time contexts, spatial extents of measurements, levels of sophistication in controlling for other possible predictors, and findings. For these reasons, empirical evidence on transit's capitalization impacts should generally be applied only for the same area where the evidence is drawn. One should be cautious in attempting to transfer evidence across metropolitan areas, not only for the problems mentioned above, but also because real estate market dynamics differ so much across regions of the country.

Empirical evidence is probably best suited to imputing accessibility and agglomeration benefits in some of the larger rail-served metropolitan areas that have been the subject of considerable past research. In the San Francisco Bay Area, for example, a number of studies, most related to the original BART Impact Study and the recent 20-year update, provide evidence on BART's capitalization effects as a function of distances for different classes of stations across distinct land use classes. As a clear-cut example of applying empirical evidence to estimate accessibility and agglomeration benefits, one can use the evidence on BART's land use and capitalization impacts.

In this example, we will measure the value-added from accessibility/agglomeration gains for the four land use categories for which BART has been shown to have yielded capitalization benefits: single-family residential (Table 9.6); multi-family residential (Table 9.7); offices (Table 9.8); and commercial-retail (Table 9.9). For these land uses, past studies provide some evidence on how premiums (and disvalues) have changed over distance categories within defined impact zones. In the absence of better information, one can average across the findings of separate studies, or perhaps choose the findings from the most recent work. We also need a time context to carry out the work. Here we can borrow from the recent findings of the "BART @ 20" study that documented the amount of development that occurred around 25 of BART's 34 stations during the 1973-1993 period (see Cervero, 1995). To carry out the analysis, we need to first obtain basic inputs, and then apply them to an adapted version of Equation 1.

<u>Amount of Development</u>

From the BART @ 20 study, Table 9.12 presents inventory summaries of land use development that were recorded for impact zones, defined as half-mile rings around stations, except downtown San Francisco and Oakland, wherein quarter-mile ring impact areas were used. Data are further stratified by metropolitan location of station areas: CBD, urban, and suburban.[52]

[52] Office development is shown only for private offices. Government and institutional offices are excluded from this analysis.

Land Value and Rent Premiums

From Tables 9.6 through 9.9, we see that since 1970 there have been the following number of studies on the capitalization effects of BART: single-family residences – 5; multi-family residences – 4; offices – 3; and commercial-retail – 2. As noted, the relationship between capitalization effects and distance from stations has been fairly well documented in the case of BART relative to most other North American rail systems. Some BART impact studies also stratify findings by metropolitan location. In general, study findings are fairly consistent. The only notable discrepancy is with respect to capitalization impacts on single-family residences close to BART stations. Early work by Dornbush (1975) recorded disvalue for residences in newer suburban settings that were situated within 400 feet of stations; other work, such as by Davies (1970), found no such disvalues, although his work did not concentrate on blocks immediately surrounding BART stations. Dyett et al. (1979) also found no disamenities associated with being near BART stations, although their work concentrated mainly on mature urban station areas as opposed to newer suburbs. More recent work by Landis et al. (1995) found that residences near East Bay BART stations in Contra Costa County, a fairly new suburban setting, actually commanded rent premiums. These more recent findings on capitalization impacts on nearby single-family residences will be used here.

For purposes of estimating accessibility/agglomeration benefits, empirical findings from past BART studies that were expressed in terms that were most compatible with how land use inventories were reported in the BART @ 20 study (shown in Table 9.12) were used. In the case of single-family residences, the work of Dyett et al. (1979) was mainly used to represent premiums, supplemented by work by Landis et al. (1995) that provided more complete information for suburban settings. The value added per unit is based on the mean value of single-family residences for each metropolitan setting reported in these two studies, expressed in 1997 dollars. For multi-family housing, findings from Bernick et al. (1995) and Cervero (1996) were adopted. For offices, findings from Falcke (1978) and Landis and Lotzenheimer (1995) were merged; premium estimates were based on averages computed from these two studies. And for commercial-retail, Falcke's 1978 results were relied upon. Estimated premiums, shown in Tables 9.13 through 9.17, are expressed for distance intervals that are most commonly used in these studies.

Additional Assumptions

In addition to these inputs, several assumptions need to be adopted to carry out the calculations. These assumptions can be dispensed with in instances where data are available or can be readily compiled. The necessity to make assumptions can be overcome given enough resources – namely the budget needed to fully compile and organize needed input data. In the absence of such resources, however, reasonable assumptions can be made. What is important is that analysts be *explicit* about the assumptions invoked. One can easily change assumptions, say based on inputs from a Delphi process or a focus group session. Indeed, the very nature of sensitivity analysis involves perturbing assumptions to trace effects on outcomes. It is in this spirit that assumptions should be drawn.

Table 9.12 Inventory of Land Uses Around 25 BART Station Areas, 1973 and 1993

Land Use		Amount of Development							
		1973 (pre-BART)				1993 (20 years after)			
Category	Units	CBD	Urban	Suburban	Total	CBD	Urban	Suburban	Total
Single-Family Residential	No. of units	220	2,680	6,030	8,930	205	2,750	6,915	9,870
Multi-Family Residential	No. of units	2,455	9,535	6,490	18,480	3,420	10,085	11,255	24,760
Office	Building, sf. (1,000)	18,425	2,700	1,805	22,930	34,655	2,770	7,065	44,490
Commercial-Retail	Building, sf. (1,000)	11,205	2,895	2,720	16,820	14,830	3,070	6,155	24,055

Source: Cervero (1995).

Table 9.13 Premiums for Single-Family Residences Within Half-Mile Impact Areas of BART Stations, for Distance Intervals *(Expressed in 1997 Dollars)*

	Average Premium per Unit (1997$)	
Distance Interval (ft.)	CBD/Urban	Suburban
0 – 500	48,960	9,140
500 – 1,000	14,400	7,930
1,000 – 1,500	8,640	3,040
2,000 – 2,500	5,760	5,500

Note: Premiums reported in Dyett et al. (1979) for urban settings (and also assumed to apply to CBDs) are: 0-500 feet – +17 percent; 500-1,000 feet – +5 percent; 1,000-1,500 feet – +3 percent; 1,500-2,000 feet – +2 percent; 2,000-2,500 feet – 1 percent. Median single-family house in urban parts of the BART-served Bay Area are assumed to be valued at $288,000, in 1997 dollars. Premiums reported in Landis et al. (1995) for suburban settings are based on: a decline in value of $2.43 (in Contra Costa County) for every foot distance from station, using midpoint values for distances for each interval (e.g., values at 250 feet for the 0-500-foot interval). A proximity premium of $9,750 (based on Alameda County findings) is used for dwelling units within 1,000 feet of stations (i.e., for the 0-500 and 500-1,000-foot interval categories).

Source: Dyett et al. (1979) and Landis et al. (1995).

Table 9.14 Premiums for Multi-Family Units Within Half-Mile Impact Areas of BART Stations, for Distance Intervals *(Expressed in 1997 Dollars)*

	Average Premium per Unit (1997$)	
Distance Interval (ft.)	**CBD/Urban**	**Suburban**
0 – 1,300	$50.00	$42.30
1,300 – 2,500	$ 0.00	$ 0.00

Note: Premiums reported in Cervero (1996) are used for suburban settings (based on Pleasant Hill and Fremont station areas). For CBD/urban settings, premiums ($0.05 per square foot) reported in Bernick et al. (1994) are used. Assuming an average size of 1,000 square feet for urban multi-family unit yields a gross premium of $50 per unit.

Source: Cervero (1996) and Bernick et al. (1995).

Table 9.15 Premiums for Offices Within Half-Mile Impact Areas of BART Stations, for Distance Intervals *(Expressed in 1997 Dollars per Square Foot)*

	Average Premium per Square Foot (1997$)	
Distance Interval (ft.)	**CBD/Urban**	**Suburban**
0 – 1,300	$0.13	$0.00
1,300 – 2,000	$0.07	$0.28
2,000 – 2,500	$0.00	$0.00

Note: Insignificant or no rent premiums were recorded for San Francisco and Oakland CBDs by Landis and Lotzenheimer (1995) and Landis and Huang (1995), anywhere within a half-mile catchment. Falcke (1978) found more significant impacts in downtown Oakland, and fairly inconsequential capitalization effects in San Francisco's CBD. A weighted-average estimate of premiums was computed for CBD/urban settings (based on the shares of office space in the CBDs of San Francisco and Oakland). Based on 1993 mean rents in CBDs (expressed in 1997 currency) of $1.60 per square foot (for the 0–1,300-foot distance interval) and $1.40 per square foot (for the 1,300–2,000-foot interval), and a weighted-average premium of eight percent for the 0–1,300-foot distance interval and five percent for the 1,300–2,000-foot interval, proximity to BART is assumed to raise office rents per square foot by $0.13 for the 0–1,300-foot interval and by $0.07 for the 1,300–2,000-foot interval. For suburban BART station areas, premiums were recorded only for the 1/4- to 3/8-mile ring (roughly 1,300 to 2,000-foot distance from station), based largely on the experiences around the Walnut Creek station. Since the Walnut Creek station area, and the nearby Pleasant Hill and Concord station areas, constituted the bulk of suburban office development that took place around BART during the 1973-1993 period (Cervero, 1995), the recorded premium for Walnut Creek is assumed to apply for all suburban station areas.

Sources: Falcke (1978) and Landis and Lotzenheimer (1995).

Table 9.16 Premiums for Commercial-Retail Activities Within Half-Mile Impact Areas of BART Stations, for Distance Intervals *(Expressed in 1997 Dollars per Square Foot)*

	Average Premium per Square Foot(1997$)	
Distance Interval (ft.)	**CBD/Urban**	**Suburban**
0 – 500	$0.07	$0.24
500 – 1,000	$0.00	$0.24
1,000 – 2,500	$0.00	$0.00

Note: Premiums based on findings of Falcke: One percent for urban retail within 500 feet of stations and none otherwise; and eight percent for suburban retail within 1,000 feet of stations and none otherwise. Percent premiums were monetized based on assumed monthly retail rents of $7 per square foot in CBD/urban settings, and $3 per square foot in suburban settings, expressed in 1997 dollars.

Source: Falcke (1978).

The following assumptions were adopted to carry out this analysis.

- The monthly rent premiums associated with multi-family housing, offices, and commercial-retail development need to be spread out over the 20-year time horizon (1973 to 1993). The amount of development that occurred over this period can be assumed to have come on line at a uniform rate. This is equivalent to assuming that, on average, new development occurred midway, or in the tenth year, of the 20-year period. Since rent premiums are expressed on a monthly basis, we'll assume station area development over the 1973-1993 period existed, on average, for 120 months (10 years x 12 months). Thus, an expansion factor of 120 will be used for measuring rent premiums.

- In order to apply Equation 1 to the BART data, one must also know the total amount of development within each distance interval, using the distance intervals by which premiums are broken down in Tables 9.13 through 9.16. The BART @ 20 study did not stratify land use inventories by distance intervals within impact zones, thus some assumption must be made on how development within these zones is spread across distance intervals. This must be done for each of the four land uses.

The simplest assumption is that development is evenly spread within distance rings. This is equivalent to saying that land uses are distributed within each distance interval according to that interval's share of total land area within an impact zone. For example, Table 9.14 shows that rent premiums for commercial-retail activities vary according to whether the activities are within any one of the three distance rings: 0-500 feet; 500-1,000 feet; and 1,000-2,500 feet. The impact zone of 2,500 radial feet from a station constitutes a

450-acre land area (assuming the impact catchment takes the form of a perfect sphere around the station).[53] The land areas of 500 radial foot and 1,000 radial foot circles are 18 acres and 72 acres respectively. This, then, tells us that the area of each distance ring is: 0-500 feet = 18 acres; 500-1,000 feet = 54 acres (72 minus 18); and 1,000-2,500 feet = 378 acres (450 minus 72). Thus, the share of commercial-retail development that is assumed to exist in each ring is the following percents of total development within the impact zone: 0-500 feet – 4 percent; 500-1,000 feet – 12 percent; 1,000-2,500 feet – 84 percent. Invoking the same assumption, development can be apportioned among distance rings for the other three land uses as follows:

- Single-family residential:
  - 0-500 feet: 4 percent
  - 500-1,000 feet: 12 percent
  - 1,000-1,500 feet: 20 percent
  - 1,500-2,000 feet: 28 percent
  - 2,000-2,500 feet: 36 percent
- Multi-family residential:
  - 0-1,300 feet: 27 percent
  - 1,300-2,500 feet: 73 percent
- Office:
  - 0-1,300 feet: 27 percent
  - 1,300-2,000 feet: 37 percent
  - 2,000-2,500 feet: 36 percent

While the above assumptions are simplest to employ, in most instances they would fail to capture how urban development actually occurs around rail stations. In the case of single-family housing, development farther from stations would likely tend to be on bigger lots, so the proportion of single-family housing in the outer rings of BART impact zones (e.g., 2,000-2,500 feet) is probably somewhat smaller in reality.[54] Likewise, we would expect multi-family housing in the inner ring (0-1,300 feet) to be denser, in the form of mid-rises, four-plexes, and three-story walk-up garden apartments. In the suburbs, zoning often restricts the amount of multi-family housing that is built away from major transportation nodes, such as rail stations. Thus, the share of apartments and condominiums built in the inner distance ring is likely larger. And in the cases of office and commercial-retail activities, we know that in a competitive land market, they will generally outbid other uses for choice sites near transit stations. From casual observation, it is clear that the share of commercial-retail development within the 0-500-foot ring of BART

[53] Given that the area of a circle equals πr^2, where r equals the circle's radius in linear feet, and that there are 43,560 square feet per acre, the acreage of a 2,500 radial-foot impact zone can be computed as: $[(3.1416)*(2{,}500^2)]/43{,}560 = 450$.

[54] This is probably offset somewhat by the tendency for locations closer to stations to be zoned for and occupied by non-residential activities, with more outlying areas characterized by traditional housing development.

stations is more than four percent of the commercial-retail development within 2,500 radial foot impact zones. This is especially so in CBD and urban settings. For these reasons, the distributions of development for each land use were adjusted, and assumed to be as follows (for both CBD/urban and suburban settings):

- Single-family residential:
  - 0-500 feet: 4 percent
  - 500-1,000 feet: 12 percent
  - 1,000-1,500 feet: 20 percent
  - 1,500-2,000 feet: 32 percent
  - 2,000-2,500 feet: 32 percent
- Multi-family residential:
  - 0-1,300 feet: 40 percent
  - 1,300-2,500 feet: 60 percent
- Office:
  - 0-1,300 feet: 40 percent
  - 1,300-2,000 feet: 40 percent
  - 2,000-2,500 feet: 20 percent
- Commercial-retail:
  - 0-500 feet: 30 percent
  - 500-1,000 feet: 30 percent
  - 1,000-2,500 feet: 40 percent

Merging these apportionments with Table 9.12 produces Table 9.17, showing estimates of development within each distance interval for the 25 BART stations, as of 1993.[55]

[55] Recall that calculations are made for the total development in the "after" or "with" period of analysis, since all development (old and new) capitalize accessibility and agglomeration benefits.

Table 9.17 Estimates of Development Within Distance Intervals of 25 BART Station Areas, 1993

Land Use Category (Measurement Units)	Distance Interval (ft.)	Amount of Development, 1993		
		CBD/Urban	Suburban	Total
Single-family residential (number of units)	1) 0 – 500	118 units	277 units	395 units
	2) 500 – 1,000	355	830	1,185
	3) 1,000 – 1,500	591	1,383	1,974
	4) 1,500 – 2,000	946	2,213	3,159
	5) 2,000 – 2,500	946	2,213	3,159
Multi-family residential (number of units)	1) 0 – 1,300	5,402 units	4,502 units	9,904 units
	2) 1,300 – 2,500	8,103	6,753	14,856
Office (thousands of square feet)	1) 0 – 1,300	14,970 sf. (000)	2,826 sf. (000)	17,796 sf. (000)
	2) 1,300 – 2,000	14,970	2,826	17,796
	3) 2,000 – 2,500	7,485	1,413	8,898
Commercial-Retail (thousands of square feet)	1) 0 – 500	5,730 sf. (000)	1,847 sf. (000)	7,577 sf. (000)
	2) 500 – 1,000	5,730	1,847	7,577
	3) 1,000 – 2,500	7,160	2,462	9,622

Calculations

With the inputs from Tables 9.13 through 9.17 and the assumptions invoked above, we are ready to calculate the accessibility/agglomeration benefits associated with BART station area development over the 1973-1993 period. Adapting Equation 1 to the data at hand, the following formula for carrying out this calculation is used:

$$B = \sum_{k=1}^{3} \sum_{s=1}^{2} \sum_{d=1}^{n_k} \left[(A_{ksd} \lambda_{ksd}) E_k \right] \quad \text{(Equation 3)}$$

where:

B = Benefit (total, in dollars)

A_{ksd} = Amount of development in land use category k (1, 2, 3, 4), setting category s (1, 2), and distance interval d for land use category k

γ_{ksd} = Land value or rent premium in land use category k, setting category s, and distance interval d

E_k = Expansion factor for land use categories k (2, 3, 4 – i.e., multi-family housing, offices, commercial-retail); E_k = 2, 3, 4 = 30

k = Land use category (1 = single-family residential; 2 = multi-family residential)

3 = Offices, (4 = commercial-retail)

d = Distance category; for $k = 1$: 1=0-500 feet; 2=500-1,000 feet; 3=1,000-1,500 feet;

4 = 1,500-2,000 feet; 5=2,000-2,500 feet; for $k = 2$: 1=0-1,300 feet; 2=1,300-2,500 feet; for $k = 3$: 1=0-1,300 feet; 2=1,300-2,000 feet; 3=2,000-2,500 feet; for $k = 4$: 1=0-500 feet; 2=500-1,000 feet; 3=1,000-2,500 feet

s = Setting category (1 = CBD/urban; 2 = suburban)

n_k = Number of distance intervals in land use category k; for $k = 1$, $n1 = 5$; for $k= 2$, $n2 = 2$; for $k = 3$, $n3 = 3$; for $k = 4$, $n4 = 3$

Inputting appropriate data from Tables 9.13 through 9.17 into Equation 3 produces the following estimate of accessibility/agglomeration benefits for the 25 BART stations over the first 20 years of service (broken down for each land use category k and setting category s):

Single-Family Residential (k=1), CBD/Urban (s=1):
[(118*48,960) + (355*14,400) + (591*8,640) + (946*5,760) + (946*2,880)] = ***$ 24,169,000***

Single-Family Residential (k=1), Suburban (s=2):
[(277*9,140) + (830*7,930) + (1,383*3,040) + (2,213* 5,500) + (2,213 * 4,280)] = ***$ 34,961,000***

Multi-family Residential (k=2), CBD/Urban (s=1):
[[(5,402*50) + (8,103*0)] * 30] = ***$ 8,103,000***

Multi-family Residential (k=2), Suburban (s=2):
[[(4,502*42.30) + (6,753*0)] * 30] = ***$ 5,713,000***

Offices (k=3), CBD/Urban (s=1):
[[(14,970,000*0.13) + (14,970,000*0.07) + (7,485,000*0)] * 30] = ***$ 88,740,000***

Offices (k=3), Suburban (s=2):
[[(2,826,000*0) + (2,826,000*0.28) + (1,413,000*0)] * 30] = ***$ 23,738,000***

Commercial-Retail (k=4), CBD/Urban (s=1):
[[(5,730,000*0.07) + (5,730,000*0) + (7,160,000*0)] * 30] = ***$ 12,033,000***

Commercial-Retail (k=4), Suburban (s=2):
[[(1,847,000*0.24) + (1,847,000*0.24) + (2,462,000*0)] * 30] = ***$ 26,597,000***

TOTAL = $24,169,000 + $34,961,000 + $8,103,000 +$5,713,000 + $88,740,000 + $23,738,000 + $12,033,000 + $26,597,000 = ***$224,054,000***

In summary, based on the methods, data inputs, and assumptions presented, it is estimated that the 25 BART station areas studied generated nearly $225 million in accessibility and agglomeration benefits.[56] The accessibility benefits of BART likely far exceed this total since properties beyond impact zones, which are far greater in number than properties included in this exercise, no doubt accrue accessibility benefits to some degree, however infinitesimally small they might be. Even if most past studies have not successfully measured capitalization benefits beyond half-mile impact zones, this is likely more an artifact of data limitations than the absence of BART's accessibility benefits being geographically dispersed.[57] Still, given the data inputs and assumptions made, $224 million is likely a reasonable estimate of the accessibility/agglomeration benefits associated with station area development for these 25 BART stations.

It appears that downtown offices have reaped the greatest accessibility/agglomeration benefits – roughly 40 percent of the total. The second most benefiting activity has been suburban single-family homes, followed by suburban retail and urban single-family housing. Station area apartment-dwellers and condominium owners appear to reap the fewest accessibility benefits, in large part because they are less prevalent. With current BART efforts to promote transit villages around selected stations, however, this could change over time (see Bernick and Cervero, 1997).

Second-Order Impacts

Compact mixed-use development around rail transit stations can set into motion a series of second-order impacts. The additional transit ridership resulting from more compact transit-oriented development, for example, will benefit society at large (e.g., less traffic congestion) and transit agencies (e.g., more farebox revenues).

Estimating Ridership Impacts of Rail-Induced Growth

Given sufficient input data, second-order ridership impacts of station area growth can be estimated by borrowing from past research. To get at ridership impacts, one can compare the likely modal split differentials between development within versus beyond a walking distance (quarter- to half-mile) of a transit station. Particularly good data on transit modal splits as functions of distances to transit stations are available from metropolitan Washington, DC, Toronto, Edmonton, and several rail-served regions of California (San

[56] It should be recalled that accessibility benefits accrue to all land use categories, while agglomeration benefits accrue primarily to offices and commercial-retail land uses, and perhaps secondarily to transit-oriented multi-family housing. None of the measured benefit for single-family housing, however, likely includes any agglomeration benefit component. Rather, it exclusively reflects the capitalized value of accessibility benefits.

[57] It should be noted that some studies found accessibility benefits that extended beyond half-mile impact zones. Landis et al. (1995), for example, estimated that BART-induced capitalization benefits for single-family homes extended more than 10 miles beyond many East Bay stations.

Francisco-Oakland, San Diego, and Sacramento).[58] Findings on how modal split gradients taper with distance for residential land uses in these three settings are summarized in Figure 9.17.[59] Findings for office land uses are summarized in Figure 9.18.

Using empirical evidence from Figure 9.17 or other sources, and other data inputs, the second-order ridership benefits of station area development might be estimated using Equation 4:

$$R = \sum_{k=1} \sum_{d=1} \left[(A_{ksd(w)} A_{ksd(wo)}) T_{kd} \right] \left(\gamma_{ksd(w)} - \gamma_{ksd(wo)} \right) \quad \text{(Equation 4)}$$

R = Ridership increase from compact, transit-oriented development for land use category k

$A_{kd(w)}$ = Amount of development of land use category k and distance interval d, with rail transit services

$A_{kd(wo)}$ = Amount of development of land use category k and distance interval d, with rail transit services

T_{kd} = Trip generation rates for land use category k and distance interval d (e.g., daily motorized trips per 1,000 square feet)

$\gamma_{kd(w)}$ = Transit modal split capture rate for land use category k and distance interval d (e.g., percent of motorized trips by transit), with rail transit services

$\gamma_{kd(wo)}$ = Transit modal split capture rate for land use category k and distance interval d (e.g., percent of motorized trips by transit), without rail transit services

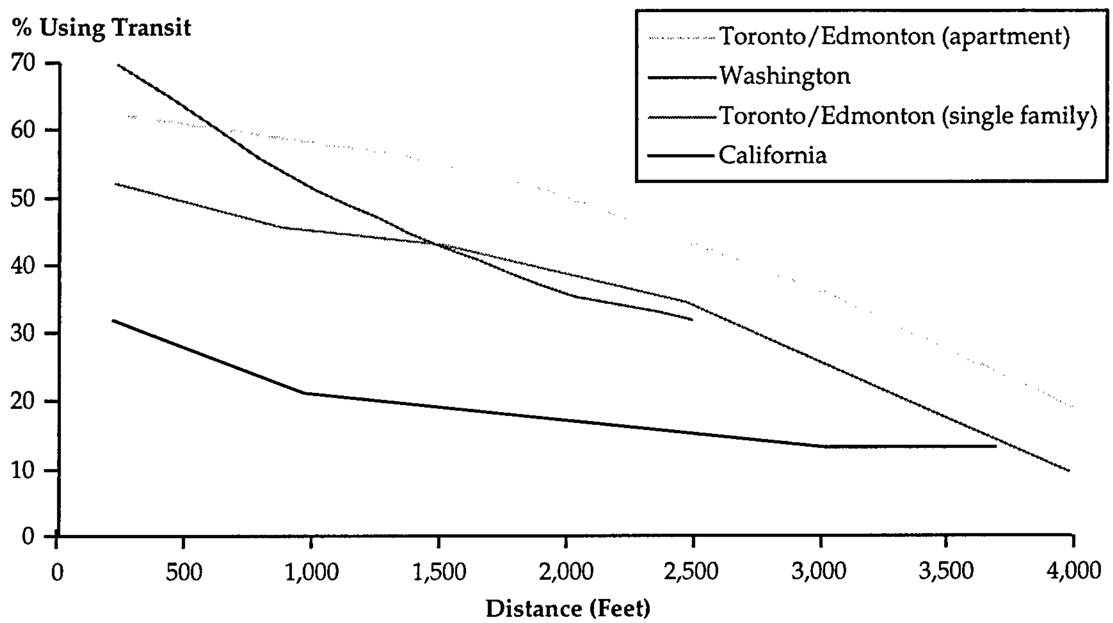
k = Land use category

d = Distance interval

[58] See JHK and Associates (1987, 1989); Cervero (1993); and Stringham (1982). In California, rail's modal shares fell by about 1.1 percent for every 1,000 foot increase in walking distance to rail stations. Higher rates in metropolitan Washington, DC (mainly based on experiences in Arlington, Virginia) and Toronto/Edmonton, Canada likely reflect the following characteristics of these areas (relative to California): higher residential densities; higher primacy (e.g., larger shares of the regional workforce in downtowns); better feeder bus connections; more extensive and more frequent rail services; and perhaps even better quality station area walking environments.

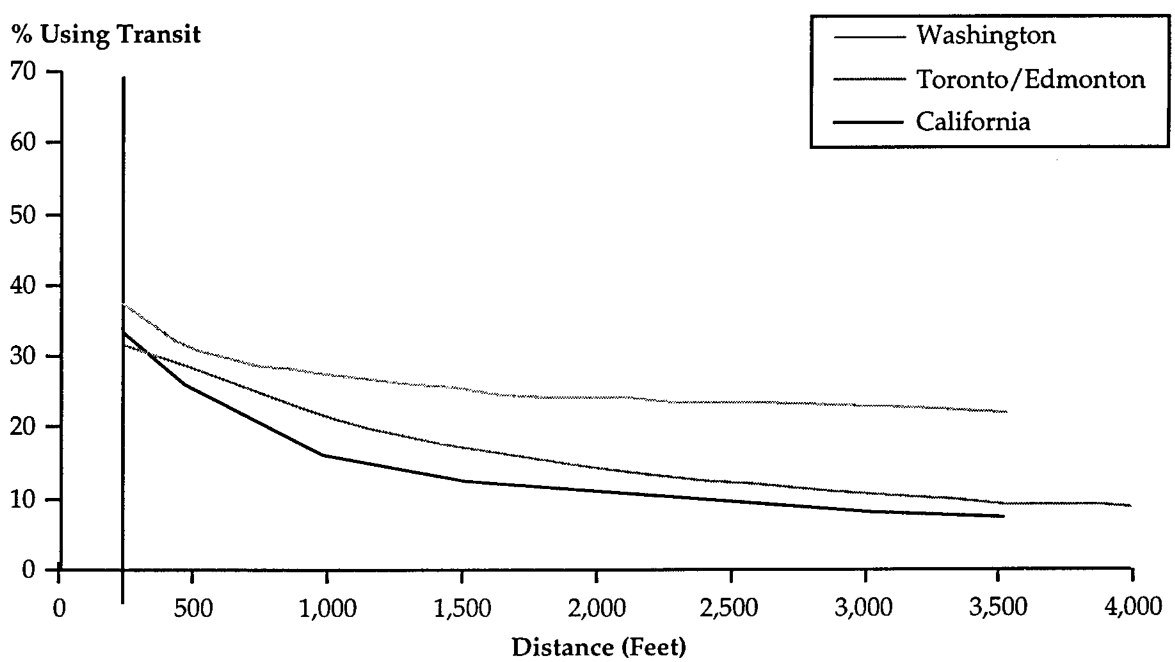
[59] Findings from California and metropolitan Washington, DC are for multi-family residences. Canadian findings are for all residential types.

Figure 9.17 Transit Modal Shares for Station Area Residences by Distance to Stations: Comparison of Experiences in Toronto/Edmonton, Metropolitan Washington, and Rail-Served Parts of California



Source:Cervero (1993) and Bernick and Cervero (1997).

Figure 9.18 Transit Modal Shares for Station Area Office Workers by Distance to Stations: Comparison of Experiences in Toronto/Edmonton, Metropolitan Washington, and Rail-Served Parts of California



Source:Cervero (1993) and Bernick and Cervero (1997).

Example: Measuring Ridership Impacts

Assumptions and Inputs

Data from the BART @ 20 study, Figures 9.17 and 9.18, and trip generation references can be applied to Equation 4 to estimate the ridership induced by station area growth. To compute an estimate, let's assume the following:

- Ridership gains associated with station area growth only accrue to two land uses: multi-family residential and offices. In the case of BART, this is largely supported by empirical evidence (Cervero, 1993).

- Motorized trip generation rates from the ITE (1991) Trip Generation manual are assumed to apply. A daily rate of 6.5 trips per multi-family household is assumed.[60] A daily rate of 10 trips per 1,000 square feet of office is also assumed.[61] For both land uses, trip rates are not thought to vary by distance from stations.

- Transit-induced growth is represented by the differences in development "before" (in 1973) and "after" (in 1993) BART. This assumes no new development would have occurred in these half-mile radius station areas between 1973 and 1993 without BART being built.[62]

- Transit modal splits for station area residents in the "without" scenario are assumed to match the regional 1991 average transit modal split (for all trips) of three percent, as reported from the 1991 Bay Area Travel Survey (BATS). Because of the tendency of offices to be in more compact transit-served settings (i.e., relatively good bus services in the absence of BART), a higher modal split of five percent is assume for offices in the "without" scenario.

- No distinctions are made in trip generation rates and transit modal splits between CBD/urban and suburban settings (since little is known about these variations and empirical results shown in Figures 9.17 and 9.18 do not make such distinctions). Thus, total amounts of single-family and office development for both 1973 (pre-BART: "without") and 1993 (20 years after: "with") shown in Tables 9.12 and 9.17 are used.

- Distance intervals are expressed according to how land use inventories were reported in the BART @ 20 study for the two land uses. Thus, average transit modal splits are imputed from Figures 9.17 and 9.18 based on midpoint values for the distance intervals used.

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[60] This is the average weekday vehicle trip rate for apartments (ITE land use category 220).

[61] This is the average weekday vehicle trip rate for general office buildings (ITE land use category 710), based on an assumed average office building size of 400,000 square feet.

[62] This is likely a liberal assumption in the sense that some new development would have probably occurred in these areas, although the amount would surely have been far less than with BART and it would have not been physically oriented to BART. Alternately, one could assume that a certain percentage of station area growth would have occurred anyway, based, say, on the amount of growth for a land use that took place during the 1973-1993 period for the city in which a station resides. For simplicity sake, the assumption that all new growth is induced by BART is adopted.

- Modal split experiences reported in Figures 9.17 and 9.18 for California are representative of the BART system.

Given these assumptions, the data inputs can be organized as follows to facilitate the use of Equation 4. Table 9.18 summarizes the amount of 1993 multi-family and office station area development "with" and "without" BART for the 25 stations under study. The difference is assumed to be induced growth. Table 9.19 summarizes the assumed transit modal splits for each distance interval, using midpoint values from Figures 9.17 and 9.18.

Table 9.18 Assumed 1993 Single-Family and Office Station Area Development With and Without BART *(for 25 Station Areas)*

Land Use Category (Measurement Units)	Distance Interval (ft.)	Amount of Development: Without[1]	With[2]
Multi-family residential (number of units)	1) 0 – 1,300	7,392 units	9,904 units
	2) 1,300 – 2,500	11,088	14,856
Office (thousands of square feet)	1) 0 – 1,300	9,172 sf. (000)	17,796 sf. (000)
	2) 1,300 – 2,000	9,172	17,796
	3) 2,000 – 2,500	4,586	8,898

[1] Represents amount of development in 1973, prior to BART's opening. These values were derived in a similar manner to how the figures in Table 9.17 were produced. The same prorations of land development across distance intervals, used in calculating 1993 totals in Table 9.17, were assumed to apply in 1973.

[2] Represents amount of development in 1993, 20 years after BART's opening and that is assumed to be induced by BART. Values are from Table 9.17.

Table 9.19 Assumed Transit Modal Splits With and Without BART *(for 25 Station Areas)*

Land Use Category	Distance Interval (ft.)	Transit Modal Splits (%): Without[1]	With[2]
Multi-family residential	1) 0 – 1,300	3	22
	2) 1,300 – 2,500	3	16
Office	1) 0 – 1,300	5	20

[1] For multi-family residential, assumed to represent the 1991 regional transit modal split of around three percent for all trips. A higher modal split for office workers is assumed based on the tendency of offices to be in more compact settings better served by bus and other forms of transit.

Sources: Cervero (1993).

Calculation

Using data from Tables 9.18 and 9.19, and invoking the assumptions, the average daily ridership impacts of transit-oriented growth around the 25 BART stations can be computed using Equation 4, stratified by the two land use categories:

Benefit (residential) = [(450,000 * -$0.30) + (850,000 * $1.75) + (1,400,000 * $1.00) + (1,700,000 * $0.60)] =	*$ 3,820,000*
Benefit (commercial) = [(160,000 * $3.50) + (120,000 * $1.25) + (100,000 * $0.75) + (80,000 * $0.50)] * 30 =	*$24,750,000*
TOTAL BENEFIT: $3,772,500 + $24,750,000 =	**$28,570,000**
Multi-family Residential (*k*=1): { [((9,904-7,392)*6.5)*(.22-.03)] + [((14,856-11,088)*6.5*(.16-.03)] } =	**6,286**
Offices (k=2): { [((17,996-9,172)*10)*(.20-.05)] + [((17,996-9,172)*10)*(.11-.05)] + [((8,898-4,586)*10)*(.09-.05)] } =	**20,255**
TOTAL: 6,286 + 20,255 =	**26,541**

Thus, based on the assumptions and empirical data used, it is estimated that some 26,500 daily trips are a result of transit-oriented, multi-family housing and office development around 25 BART stations. Around three-quarters of this total is attributable of station area office growth. This estimated 26,500 daily growth-induced BART trips constitutes around 10 percent of BART's current total daily ridership.

From the perspective of many transit agencies, the bottom-line benefit of transit-induced growth is increased farebox revenues. Applying an average fare per trip, the revenue implications of transit-induced growth can be estimated. In BART's case, the average fare per trip in 1993 was around $2.[63] Thus, the estimated amount of additional daily fare revenues generated in 1993 by transit-induced growth around the 25 stations is: 26,541 daily trips * $2/trips = $53,082.

Conclusion

Using empirical evidence from land markets is one of the most promising and straightforward approaches to getting at transit's accessibility and agglomeration benefits. Simple algebraic formulas can be used to generate estimates, drawing from available empirical data and intuitive assumptions. By defining the spatial extent of transit's capitalized land value and rent premiums, and by capturing the relationship between price and distance, one can easily multiply premiums by land use quantities and integrate the

[63] BART uses distance-based fares. Transbay fares, between the East Bay and San Francisco, are the highest. Since Transbay trips constitute a large share of daily journeys, especially for office workers, average fares per trip tend to be relatively high.

results across distance categories to arrive at plausible estimates. And given knowledge of how transit modal splits vary with distances from stations, a topic that has gained increasing research attention in recent years, one can extend the analysis to measure second-order impacts – namely how ridership and farebox revenues might increase as urban growth clusters around transit stops.

For the most part, there is sufficient empirical evidence to carry out these analyses for some of the larger metropolitan areas of the country with relatively new rail systems. While some assumptions will likely have to be adopted in applying these methods, as is the case with virtually any method, the assumptions themselves can be perturbed to allow for sensitivity analyses. Also, qualitative approaches, such as Delphi and focus group techniques, can be used to set and refine assumptions. As empirical evidence on transit and land use relationships continues to mount, we can expect the methods presented in this section to have even broader applicability in years to come.

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